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REPORT OF INVESTIGATIONS 194

GROUNDWATER GEOLOGY OF LEE AND WHITESIDE COUNTIES, ILLINOIS

BY

JOHN W. FOSTER

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS

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May 16, 1955

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CONTENTS

ILLUSTRATIONS

GROUNDWATER GEOLOGY OF LEE AND WHITESIDE COUNTIES, ILLINOIS

BY

JOHN W. FOSTER

ABSTRACT

Geologic conditions in Lee and Whiteside counties favor occurrence of usable quantities of groundwater, although depths to water-bearing formations and the type and cost of well construction vary markedly from area to area. Seven bedrock formations and several sand and gravel formations yield appreciable supplies of potable groundwater. The report describes the occurrence, water-yielding characteristics, and drilling conditions of the important formations known in the two counties. Groundwater possibilities in each of the 44 townships are summarized and suggestions are made on planning domestic, industrial, and municipal water wells. Geologic conditions influencing the amount and quality of groundwater at each of the major communities are summarized and suggestions for future groundwater development are given. Further development is favorable in extensive areas where shallow low-cost supplies, at present largely unexploited, are available.

INTRODUCTION

Lee and Whiteside counties are well endowed with groundwater resources. Few counties in Illinois have such promising undeveloped groundwater supplies.

The availability of groundwater depends on geologic conditions, which vary from place to place. The purpose of this report is to describe these conditions in Lee and Whiteside counties and indicate the availability of groundwater. Interpretation of the geology and its bearing on the accumulation of groundwater is useful to rural residents, farm advisers, drilling contractors, industrial engineers, consultants, and others who deal with groundwater development in these counties. Drilling at any location can then be made with advance knowledge of the formations likely to be encountered and the probable depths of proposed wells.

An understanding of the earth formations from which supplies of groundwater can be obtained is desirable if this report is to be used to best advantage. Three types of formations are known to contain usable groundwater in Lee and Whiteside counties:

1. Sand and gravel beds above solid rock. Sand and gravel deposits have the greatest water-yielding potential. They occur only at certain places in the counties.

2. Dolomitic rocks. Dolomite is similar in appearance to limestone and is often popularly so-called. Dolomites are numerous; at least one of them occurs almost continuously throughout the counties. Dolomite yields groundwater only through open cracks or solution channels because little water moves through the dense rock itself.

3. Sandstone. At least one sandstone bed can be found at any location in these counties. These beds are valuable and reliable sources of major groundwater supplies, but they are not always the most practical to develop, especially where shallow water-bearing sand and gravel deposits are present.

These counties should be considered not only as a map area, but as a block of the earth containing a third dimension, depth (fig. 2). Conditions within this dimension basically control the occurrence of groundwater and the cost of well construction.

Investigation of the groundwater in Lee and Whiteside counties raises many interesting geologic problems that lie for the most part beyond the scope of this report. This region has been studied and the report written expressly for those who need information on groundwater resources.

This report is based largely on new information on groundwater geology which

has been integrated with data previously obtained by others. Data have been obtained from drillers, from samples of drill cuttings, from farmers and engineers, and by personal field observation. Topographic maps of most of the region and aerial photographs of the entire region have been used to great advantage. All basic data are on file at the State Geological Survey in Urbana.

Acknowledgments

The author acknowledges the help and guidance of Frank C. Foley, formerly Head of the Groundwater Division, George E. Ekblaw, Head of the Division of Engineering Geology and Topographic Mapping, Arthur Bevan, Principal Geologist and Head of the Geological Resources Section, and H. B. Willman, Head of the Division of Stratigraphy and Areal Geology, Illinois State Geological Survey. Unpublished data obtained by the late J. S. Templeton of the Survey have been used in the areal geologic mapping. Ross Hanson, Associate Engineer, Illinois State Water Survey, has been helpful in classifying some areas as to their groundwater possibilities. Additional credit is due the many drilling contractors in northern Illinois who provided logs, drill cuttings, and other valuable data on subsurface conditions.

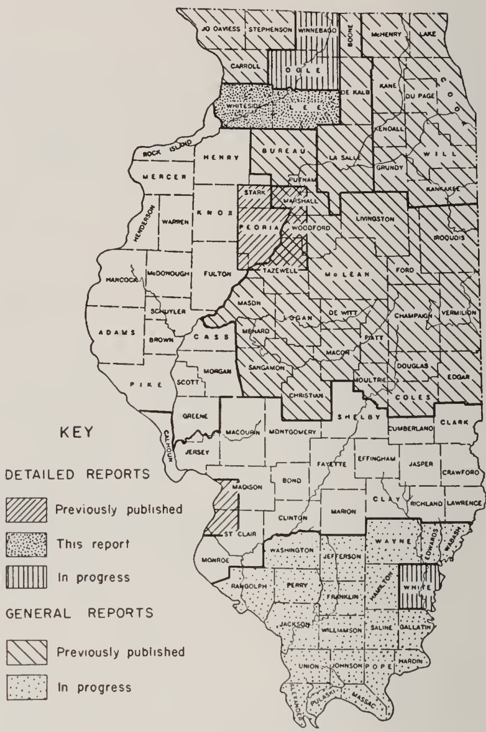


Fig. 1.—Index map.

GEOGRAPHY AND GEOLOGY

Surface

The land surface in Lee and Whiteside counties is one of contrasts—from the broad lowlands of the Green River Valley to rolling uplands in the north and southeast. Leighton, Ekblaw, and Horberg (1948) consider the land surface features as belonging to three landscape provinces—the Rock River hill country in the north, the Green River lowland, and, in southeastern Lee County, the Bloomington ridged plain. In Whiteside County the sandy plains of the Green River lowland occupy most of the southern half of the county, whereas in Lee County these lowlands are narrow and are between the upland areas. The rolling areas north of the Green River Valley are older rock uplands. They are thinly mantled with glacial drift of Illinoian-Tazewell age. The Bloomington highlands south of the Green River Valley are younger uplands, formed by thick deposits of younger glacial drift, of Tazewell age.

The highest elevations occur in the uplands of southeastern Lee County in Brooklyn, Wyoming, and Willow Creek townships. The crests of the Bloomington glacial moraine are as high as 950 to 990 feet above sea level. The lowest elevations are in western Whiteside County; the Mississippi bottomlands at Albany are about 580 feet above sea level.

Lee and Whiteside counties comprise an area of approximately 1436 square miles. They include 19 communities of at least 100 population. Eighteen communities are served by public water systems—eleven in Lee County and seven in Whiteside County—all obtaining groundwater from drilled wells.

Subsurface

The earth's formations rest layer upon layer without much warping or faulting over a large part of these counties (fig. 2).

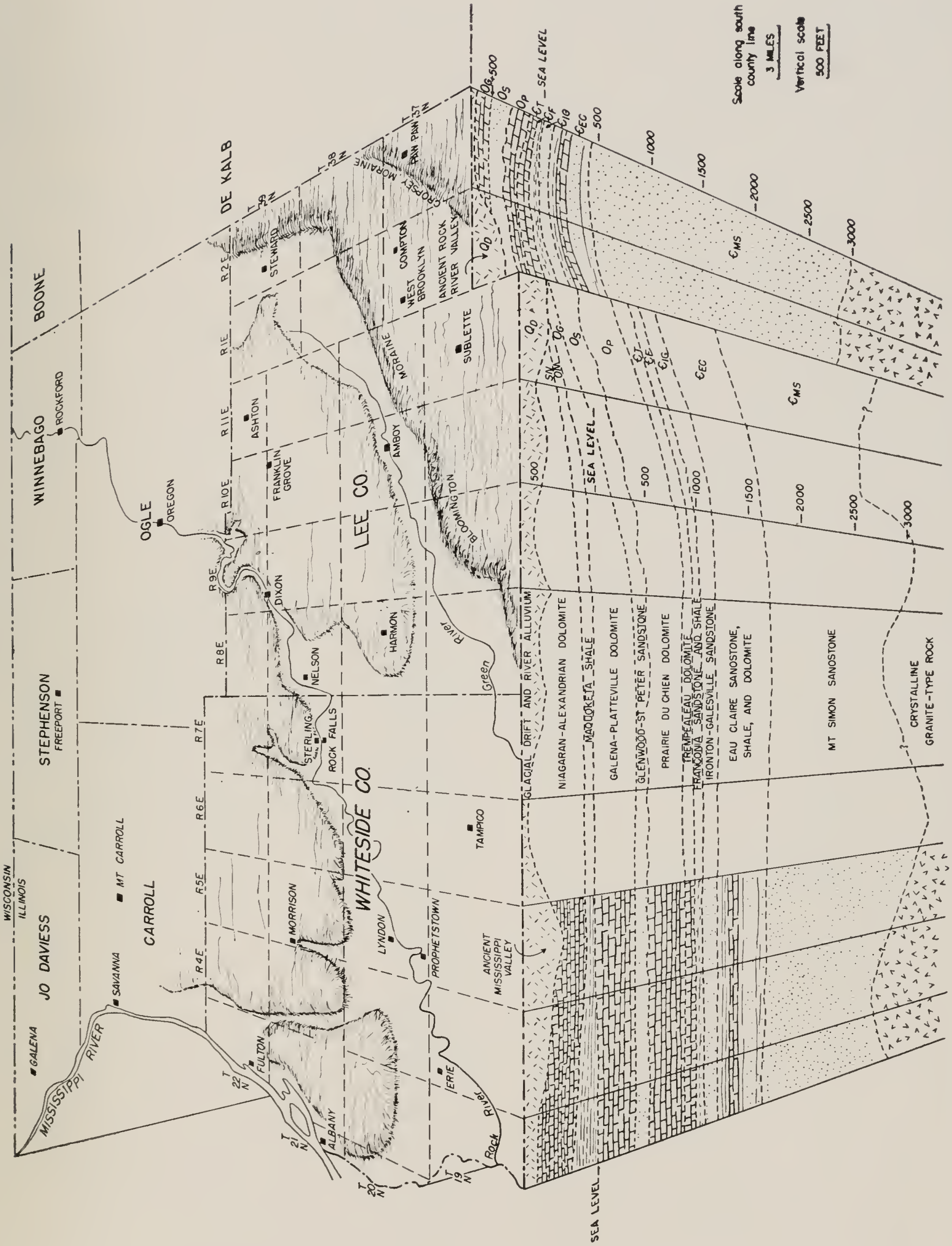


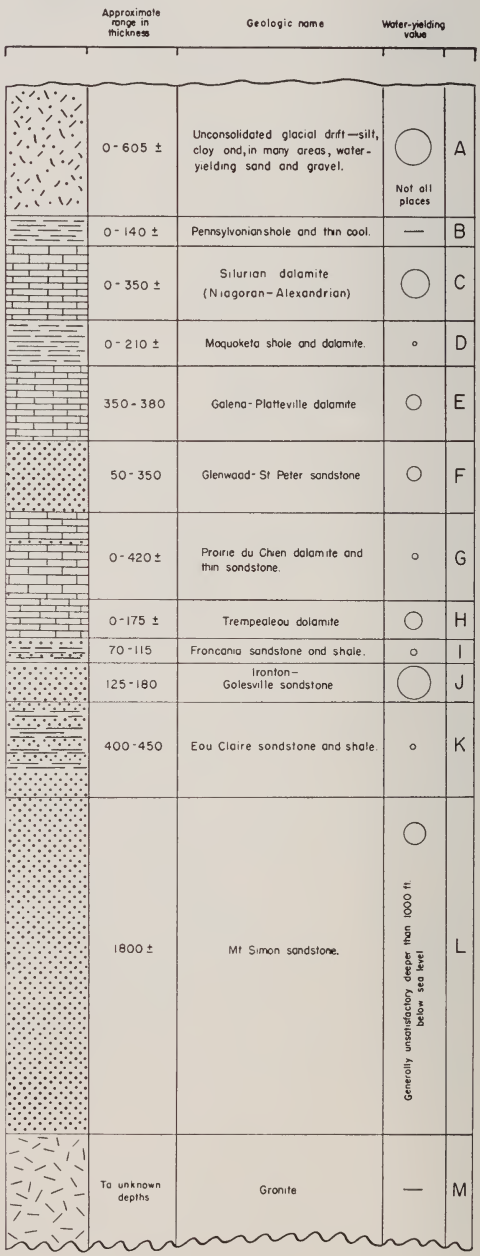
FIG. 2.—Block diagram of Lee and Whiteside counties.

The shallowest material, unconsolidated glacial drift, extends to depths as great as about 600 feet in southeastern Lee County, and rests on bedrock. In some areas, principally in the northern portions of both counties, the drift is thin or absent and bedrock is exposed. Much of the unconsolidated drift is tight pebbly clay and silt called *till*; some of the drift is water-bearing sand and gravel. Where the water-bearing sand and gravel beds are suitably thick and widespread, they are promising sources of industrial and public water supplies, more so than the better-known deep sandstone formations.

Stratified bedrock formations consisting of dolomite (a limestone-type rock), shale, and sandstone occur below the drift throughout the counties. The top of the buried rock is not smooth because for millions of years it was exposed to the same forces of erosion as the present land surface. The bedrock surface has its own uplands and valley lowlands. These ancient buried valleys in many cases contain large water-bearing sand and gravel deposits. Enormous reservoirs of groundwater occur in such buried valleys as those of the ancient Mississippi and Rock rivers. The courses of these abandoned and buried valleys bear little relation to the river courses on the present landscape.

The stratified rock formations below the glacial drift yield water to many wells in Lee and Whiteside counties (figs. 3 and 6). The formations are known to extend to 3046 feet below sea level at the site of an oil test in Lee County (T. 20 N., R. 10 E.) and are probably several hundred feet deeper at other places in these counties, far below the deepest water well. At least 55 percent of this sedimentary rock is sandstone. The proportion of sandstone to other rocks, like dolomite and shale, increases to about 85 percent in eastern Lee County. There many of the shallower dolomite and shale formations are missing as far down in the geologic column as the Trempealeau formation.

The sedimentary rocks dip gently to the southwest in Lee and Whiteside counties. For example, the top of the Galesville sandstone is about 150 feet above sea level at Ashton, Lee Co., and about 1000 feet below sea level at Erie, Whiteside Co. In 46 miles the formation dips about 1150 feet, an average dip of 25 feet to the mile. In Alto and Reynolds townships, northeastern Lee Co., the sedimentary rocks are broken and faulted along the Sandwich fault zone. In other areas, so far as is known, the rocks lie in unfaulted layers.



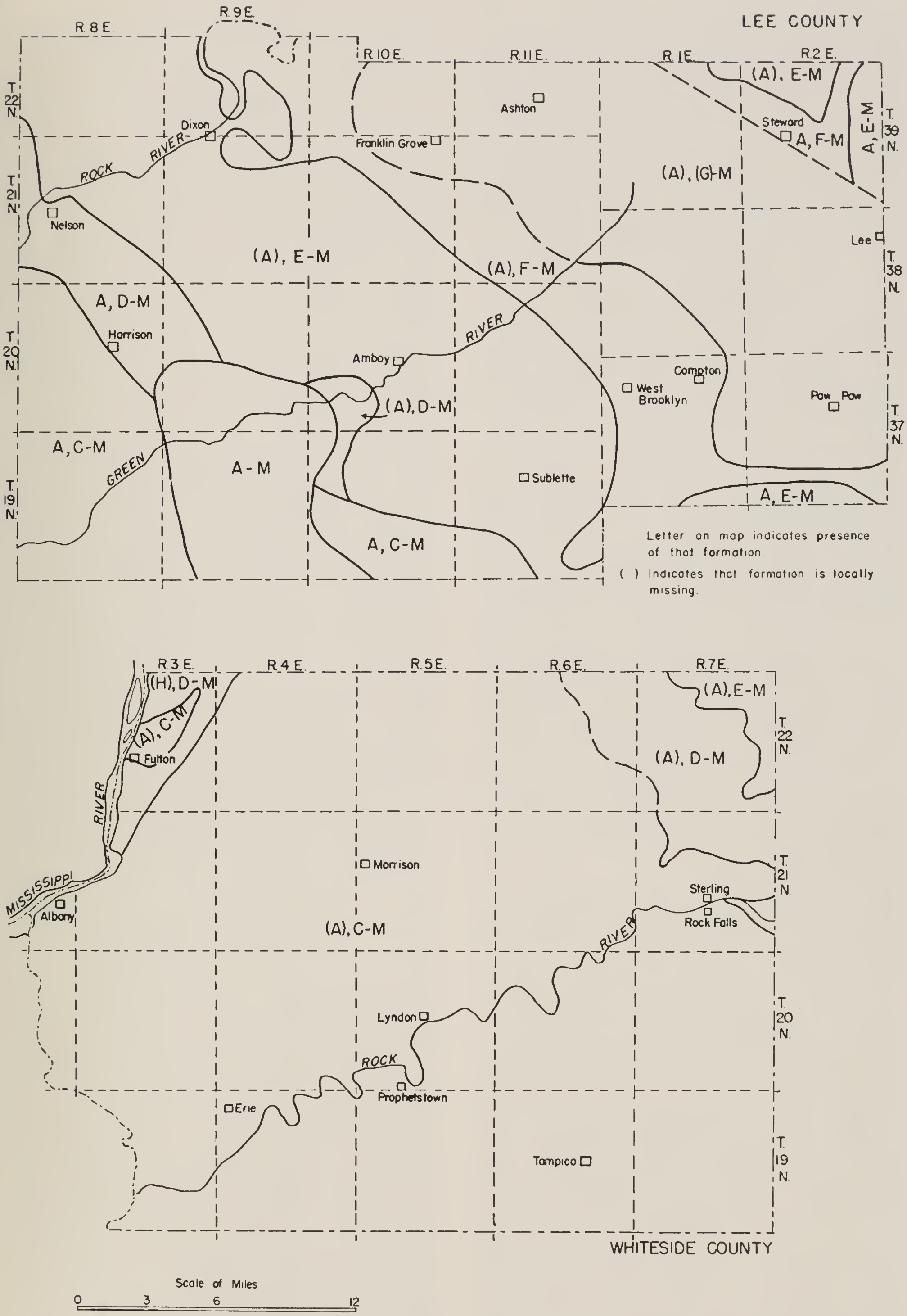


FIG. 3.—The geologic formations and their distribution, with special reference to water-bearing beds. Letters on maps refer to formations shown in chart at left.

Each of the sandstone formations and most of the dolomite yields groundwater at some location in Lee and Whiteside counties. The best sandstone is the Galesville, which is believed to occur throughout the region. It is a nearly pure-white quartz sand, similar in appearance to the shallower St. Peter formation, but more permeable because of fewer silt-size grains and somewhat more uniform grain size. The deep Mt. Simon sandstone is not widely used as a source of groundwater in this region, although it is probably a permeable formation and is believed to contain usable groundwater as deep as about 1000 feet below sea level (State Water Survey, personal communication).

Hard dolomites may yield industrial and municipal supplies of water where they are heavily fractured or contain abundant openings. As a rule the dolomites are most favorable sources where they directly underlie the glacial drift because they tend to be more extensively fractured and groundwater can more readily be recharged into the openings. The best example is the Galena-Platteville dolomite, which is a good water-bearing formation in the Amboy area, where it lies under the drift cover, but which is generally a poor water-yielding formation in central Whiteside County where it lies under Maquoketa shale.

Below the Mt. Simon sandstone, to unknown depths, lie solid granite and other crystalline rock, often called basement rock. To the north, the basement rocks rise toward the surface, and the overlying sedimentary rocks thin proportionately. Basement bedrock is exposed at scattered localities in southern Wisconsin. To the south toward the Illinois Basin, the depth to the basement increases markedly and the layered rocks above thicken proportionately. In southeastern Illinois the crystalline basement is buried to depths of at least 11,000 feet (Workman and Bell, 1948). Grogan (1949) reports on studies of two deep oil tests in Lee County, Vedovell 1, sec. 35, T. 20 N., R. 10 E., and McElroy 1, sec. 30, T. 20 N., R. 10 E., which penetrated 3652 and 3772 feet of rock, respectively. Vedovell 1 was drilled 187 feet into basement rock composed of red granite and felsite.

THE FOUR GLACIERS AND THEIR DEPOSITS

A cover of unconsolidated silt, clay, sand, gravel, and boulders overlies the bedrock at most places in Lee and Whiteside counties. Most of this material is glacial drift—debris left by water and ice from the great glaciers that spread across this part of the State. Masses of continental ice moved into parts of northwestern Illinois during three distinct stages of glaciation, all within the past million years, the last one at least as recent as 20,000 years. Few events in geologic history have so changed the landscape of this area. Not only did glaciers turn the great Mississippi from its course through southern Whiteside and Bureau counties toward its present channel near Rock Island, but they also smoothed the land, renewed the soil with minerals, and left for man a rich and fruitful countryside.

Some of the unconsolidated material consists of water-laid deposits (alluvium) in the present stream valleys, such as in the Mississippi Valley along the western edge of Whiteside County. Bedrock is exposed in some places either where drift was not deposited or where the drift cover has been completely eroded. Galena dolomite and St. Peter sandstone are exposed at many places in the Dixon area, but drift thicknesses of 200 feet are common in both counties. In parts of southeastern Lee County the depth to bedrock is probably as much as 590 to 600 feet, which is believed to be the greatest drift thickness in Illinois.

Whether or not groundwater is available from the glacial drift depends largely on the occurrence of clean beds of sand and gravel. At some locations a driller may penetrate 250 or 300 feet of drift without discovering water-yielding sand or gravel. In other places the bedrock is completely covered by water-bearing sand and gravel. Summarized below are the glaciations that have affected the area.

Nebraskan Glaciation

This glacial epoch, named for deposits in

Nebraska, is believed to be the oldest of the four Pleistocene stages. Nebraskan deposits in Illinois are known only in the western counties (Bell and Leighton, 1929). Nebraskan ice probably invaded Lee and Whiteside counties, although no deposits there have been positively identified as Nebraskan. It seems quite possible, however, that Nebraskan drift occurs in western Whiteside County, particularly on the outskirts of the Garden Plain upland between Fenton and Albany, an area that easily could have been invaded by ice moving southeastward into the Mississippi Valley.

Kansan Glaciation

Many important changes in the condition of the bedrock valleys of Illinois took place during the Kansan glacial epoch, so named for the State of Kansas which was invaded by ice during this period. Studies by MacClintock (1933) indicate that most of the eastern half of Illinois was invaded by an ice lobe of Kansan age which traveled down the Lake Michigan trough. Part of the uplands of the western half of Illinois may have remained free of Kansan ice, but Kansan ice from the northwest probably entered the low country along the present course of the Mississippi and invaded western Whiteside County. Kansan drift has not been identified definitely in the low bedrock areas of Lee County, but its occurrence in eastern Bureau County suggests that Kansan deposits may lie deeply buried in Lee County.

Illinoian Glaciation

The third glacial stage is known as the Illinoian because ice of this period, spreading from the north-northeast, covered Illinois as far south as the Ozarks of northern Johnson County. In northwestern Illinois the ice spread west across the Mississippi Valley and temporarily rerouted the Mississippi River into Iowa (Schoewe, 1923).

In the uplands of northern Whiteside County and northwestern Lee County the land surface is developed on Illinoian drift (fig. 2). Because of the scarcity of water-bearing sand and gravel in the upland area, groundwater is not easily obtained there by shallow drilled wells. South of these uplands, the landscape has been changed by a later glacier, and Illinoian deposits are either buried or have been completely eroded. Material identified as Illinoian drift has been found in a number of borings in southeastern Lee County. (Example: West Brooklyn village well 3, sec. 8, T. 37 N., R. 1 E. Depth to Illinoian drift: 286 feet. Recognition of Illinoian drift based on Sangamon leaching.)

Wisconsin Glaciation

The fourth glacial stage is called Wisconsin. Because Wisconsin glaciation is the most recent, the deposits left by Wisconsin ice have been least changed by weathering and erosion. At least five distinct advances of glacial ice occurred during Wisconsin time—Farmdale, Iowan, Tazewell, Cary, and Mankato. Studies at the University of Chicago using carbon 14* indicate that Mankato glaciation is as recent as 10,500 to 11,400 years ago in the State of Wisconsin.

Only the Tazewell ice reached the Lee-Whiteside region. Studies by Leighton (1923) showed that parts of Lee and Whiteside counties contain glacial drift, in the form of till, that is younger than Illinoian. Recent studies (Leighton and Shaffer, 1949; Shaffer, 1954) show that the lobe of early Wisconsin ice that entered the Lee-Whiteside area from the northeast, called the Green River lobe, not only swung deep into Whiteside County but crossed into Iowa for several miles, with great tongues of relatively thin ice lying in the lowland areas. Deposits from the Green River lobe are thin and are buried in many places by a mantle of wind-blown loess of fine sand and silt. Shallow Green River lobe deposits have been found several miles north of Sterling and Lyndon in Whiteside County and in a broad belt lying north of the Green

* This method of determining the age of organic material is based on measurement of its content of radioactive carbon 14. For example, in a living tree the ratio between total carbon and carbon 14 is constant, always the same as in the air, but when the tree dies the radioactive carbon 14 continues to disintegrate at a constant rate without being replenished. The approximate age of a glacial deposit (up to a limit of about 34,000 years) can be determined by measurement of carbon 14 in wood or shells occurring within the deposit.

River and south of Eldena in central Lee County.

In eastern and southeastern Lee County lies a rolling upland which overlooks the Green River lowlands to the west and northwest. Most of this highland is part of the Bloomington glacial moraine, built from the debris of the last of the Tazewell glaciers to enter the region (fig. 2). Elevations on the crest of the Bloomington moraine are 200 to 275 feet above the sandy low country. In extreme southeastern Lee County, largely T. 37 N., R. 2 E., the highest elevations are on the Cropsey moraine, which was probably formed by a readvance of the same ice mass that built the Bloomington moraine.

The Bloomington and Cropsey glacial drifts are largely tight till composed of pebbly silt and clay; boulders are common. Water-bearing sand and gravel beds are scarce. Many farm wells in the highlands of southeastern Lee County have penetrated more than 250 feet before productive sands have been found. This suggests that drilling has penetrated the entire thickness of Bloomington drift.

THE ANCIENT DRAINAGE SYSTEM

During the millions of years between the last retreat of the shallow Pennsylvanian continental sea and the coming of Pleistocene glaciers, the land was subject to the same geologic processes that carve the valleys and erode the hillsides today. The bedrock in upland areas was close to the soil, as it still is in the unglaciated Missouri Ozarks. The rivers flowed in valleys they had carved out that bear little relation to the valleys on the present surface. The old preglacial valleys are now largely abandoned, and in northwestern Illinois they are mostly buried by sand and gravel and glacial debris. They can be located by plotting the low places of the bedrock surface, generally through the use of well logs. Some of the large preglacial valleys were recognized by Leverett (1921). In 1950 a detailed study by Horberg of Illinois' bedrock surface was published as Illinois Geological Survey Bulletin 73. Figure 4 is a modification of the original map by Horberg (1950a).

Mississippi River

The ancient course of the Mississippi in northwestern Illinois lies not through the narrow gorges between Cordova and Rock Island but in an easterly course across southern Whiteside County on the northeast side of Erie. From that area the old river flowed across the northeast corner of Henry County and across Bureau County toward the present great bend in the Illinois River near Hennepin. Except where it passed a few miles east of Peoria, the Ancient Mississippi roughly followed the present Illinois Valley from Hennepin south. North of Albany, Whiteside Co., the deepest bedrock elevations appear to lie east of Fulton, indicating that the old Mississippi flowed a few miles east of the present river. The lowest bedrock elevations are probably 285 to 300 feet above sea level throughout the old bedrock channel of the Mississippi in Whiteside County.

The shift of the Mississippi to its present course occurred during a number of separate stages, each intimately connected with the various glaciations. A possible chronology of major events follows.

1. Shift of the Mississippi from its course near Albany into a new channel (now called Cattail Slough) near Fenton, probably because ice from the west blocked it near Albany during the Nebraskan and/or Kansan glacial stages.
2. Return of the Mississippi to its original course from Fulton to Albany to Erie, thence southeastward to Bureau County (post-Nebraskan and/or post-Kansan), with considerable filling of the old bedrock valley.
3. Blocking of the Mississippi Valley in western Whiteside County by Illinoian ice from the northeast, causing diversion of the Mississippi near Savanna into the Goose Lake channel in Iowa, thence into the Elkhorn and Cedar River valleys of Iowa and into an old undersized valley near Fort Madison. South from Fort Madison the temporary Mississippi followed a former

tributary valley of the Mississippi to the mouth of the present Illinois River north of St. Louis. This great diversion of the river may have been preceded by a temporary diversion at Erie into the East Moline area via Joslyn and Barstow until advancing ice from the northeast caused a diversion farther upstream.

4. Return of the Mississippi for the last time to its course through the present Illinois Valley via Albany, Erie, and Bureau County during the Sangamon interglacial epoch.

5. The Green River lobe diverted the river from its course through the Illinois Valley into the East Moline area via Joslyn and Barstow. Further movement of the ice westward dammed the river and caused it to drain across a divide near LeClaire, Iowa, through the Cordova gorge, the present position of the river.

6. The Mississippi may have then abandoned the gorge at Cordova and joined the Rock River at Erie to flow southwestward to East Moline. This problem merits additional detailed field study beyond the scope of this regional report.

7. The lowlands were filled almost to their present level with silts, sands, and gravels from strong alluviation. This fill perhaps caused final diversion of the Mississippi into the Cordova gorge, which had been previously cut to about the 600-foot level.

8. Outwash during the Bloomington stage caused further alluviation of the lowlands of Whiteside and Lee counties.

9. Strong drainage down the Mississippi during Mankato time (late Wisconsin) scoured out much of the valley fill as far east as Erie, as the river became choked by the Cordova gorge and spread out. During late Mankato time the old valley was filled almost to the previous level by Mississippi River material. Most of the Mississippi River remained in the Cordova gorge, but some flowed around the Port Byron highlands into the Rock River, marking the western boundary of Whiteside County.

Rock River

Rock River also changed its course markedly during the glacial epoch. The ancient, preglacial Rock flowed almost due south from Rockford into southeastern Lee County. Near the village of Paw Paw it turned westward across the southeast part of Lee County and joined the Ancient Mississippi in central Bureau County. The position of the buried bedrock valley (shown approximately from Steward to Paw Paw in eastern Lee County, fig. 4) has much bearing on the groundwater possibilities in the area. The old river valley is not only filled by glacial debris but is also buried under the Bloomington-Cropsey moraines. Part of southeastern Lee County therefore has apparently the thickest cover of glacial drift to be found in Illinois. It amounts to 580 to 600 feet in parts of Ts. 37 and 38 N., R. 2 E.

The diversion of the Rock River from its ancient course through eastern Lee County to its present course in western Lee and Whiteside counties involved a number of stages, each related intimately to glacial events. The following is a possible sequence of stages in the diversion of the Rock.

1. Illinoian ice and its deposits shifted the Rock River from its course due south from Rockford to a new course through the Stillman Valley to Byron, Ogle Co., thence over a series of low divides past Oregon to Grand Detour, Dixon, and Sterling. From Sterling it probably trended south to a point near the Elkhorn Creek bedrock valley and merged with the Ancient Mississippi in north-central Bureau County. This was the probable pattern of Rock drainage during Sangamon interglacial time.

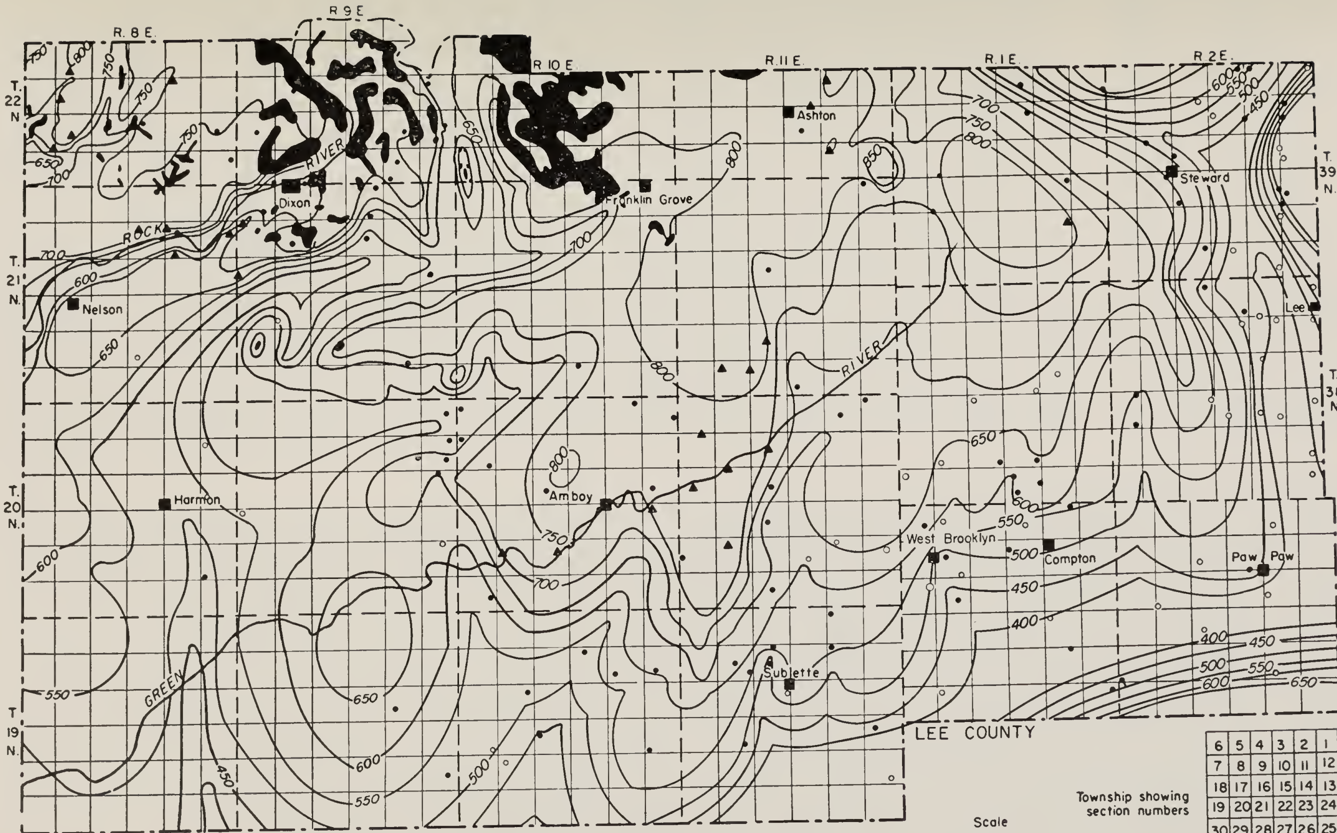
2. The Green River lobe, advancing from the northeast, buried the Rock's former valley at Sterling and diverted the river to a westerly course across Whiteside County.

3. The river has since meandered over a 4 to 6 mile belt in the sand plain west of Sterling. This is shown clearly on aerial photographs by the river's channel scars.

Green River

The Green River in Lee and Whiteside counties drains a large part of the great sand plain of the Green River lowlands. The


WHITESIDE COUNTY
Scale
0 1 2 miles
R.7E.
R.6E.
R.5E.
R.4E.
R.3E.
T. 22 N.
T. 21 N.
T. 20 N.
T. 19 N.
Sterling
Rock Falls
Tampico
Lyndon
Prophetstown
Morrison
Erie
Fulton
Albany
RIVER
ROCK
MISSISSIPPI
RIVER
Township showing section numbers



6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

FIG. 4.—Contour maps of the bedrock surface in Lee and Whiteside counties. Contours show approximate elevation of the top of the bedrock in feet above sea level. Black triangles and irregular black areas indicate rock exposed at land surface. Control points shown by circles and dots. A dot indicates precise control. *After* Horberg, Leland, 1950, Bedrock topography of Illinois.

rest is drained by the Rock. Green River dates only from the building of the great sand plain, probably in the Tazewell stage of Wisconsin glacial time. Its creation seems to be closely related to stage 2 of the Rock River's history.

SAND AND GRAVEL BEDS

Sand and gravel beds above bedrock are the largest undeveloped source of low-cost groundwater in Lee and Whiteside counties. The greatest handicap to proper utilization of these water-bearing formations has been uncertainty as to their distribution. In most municipal and industrial water programs, specifications on well construction are drawn in advance of drilling. In the past it has been customary to specify deep drilling to a known bedrock aquifer rather than to consider the possibility of finding surficial sand and gravel beds for shallow wells. However, it has been pointed out (Foster, 1953) that it is less expensive to develop the sand and gravel deposits where they occur within a reasonable distance, conserving the widerspread bedrock aquifer for development in those areas where there is no alternative to deep drilling.

There is a definite trend toward the utilization of groundwater resources in sand and gravel in northern Illinois in preference to deeper resources. The City of Rockford now obtains groundwater from sand and gravel in the old bedrock valley of the Rock River. In the fall of 1953 the Northern Illinois Water Corporation constructed a high-capacity sand and gravel well south of the Rock River in Rock Falls, Whiteside Co. The village of Erie in western Whiteside County is now using a new sand and gravel well in one of the most attractive shallow aquifers in Illinois. Groundwater possibilities in sand and gravel were obviously ignored there by contractors and engineers in 1920, however, as the first Erie well was drilled several hundred feet into solid rock, casing off nearly 200 feet of water-bearing sand and gravel.

The trend away from rock drilling has been enhanced by modern shallow-well techniques and slim-hole testing, by better understanding of the value of shallow sources, and by more geologic information on the occurrence of water-bearing sand and gravel. This report indicates the areas in Lee and Whiteside counties where shallow sand and gravel aquifers are likely to be found and gives geologic data bearing on the utilization of these little-developed resources.

Sand and Gravel Beds in Bedrock Valleys

Study of the occurrence of sand and gravel beds in the larger buried bedrock valleys in Lee and Whiteside counties is hampered by limited drilling information. The water wells on farms in this area are of minimum depth, but village wells and scattered industrial wells prove that deep sand and gravel beds occur at certain locations and enable the bedrock valley system to be plotted. Control points are shown on the bedrock contour map (fig. 4). Between control points the geologist can only infer subsurface conditions and from them predict the occurrence or absence of water-bearing deposits (fig. 5).

In Lee and Whiteside counties, as in many other parts of Illinois, ancient valleys carved in the top of the bedrock contain very promising sand and gravel aquifers. This is particularly true of those valleys that carried meltwater and rock debris away from the glaciers. Each of the larger bedrock valleys in Lee and Whiteside counties is known to contain one or more beds of sand and gravel; an outstanding example in Whiteside County is the Ancient Mississippi (Princeton) Valley. In Lee County, the most important bedrock valley is the Ancient Rock River (Paw Paw) Valley, which trended south in eastern Lee County to Paw Paw village, thence westward into Bureau County a few miles south of Sublette.

Deposits in the Ancient Rock (Paw Paw) Valley.—The ancient bedrock valley of the Rock River in eastern and southeastern Lee County contains water-bearing sand and gravel below thick clay till, as indicated by a number of widely scattered borings. Two of these records are as follows:

Chicago, Milwaukee and St. Paul Railroad well 1, vicinity SE¼ sec. 6, T. 37 N., R. 2 E., Lee Co. Est. elev.: 930 feet. Geologic interpretation from driller's log.

	Thickness feet	Depth feet
Pleistocene series		
Glacial till, clayey	272	272
Sand, fine	10	282
Gravel, medium to coarse . .	14	296

Anton Arne well, vicinity center of west line sec. 11, T. 39 N., R. 2 E., Lee Co. Elev.: 920 feet. Geologic interpretation from drill cuttings, sample set 12347.

	Thickness feet	Depth feet
Pleistocene series		
Sand, medium, silty	130	130
Sand, medium, some gravel, silty	80	210
Till, reddish brown, clayey (Shelbyville?)	55	265
Sand and gravel, silty, slightly oxidized	105	370
Sand, medium to fine, yellow, silty	40	410
Sand and gravel, clean, with dolomite fragments	45	455
Ordovician system		
St. Peter sandstone	45+	500

These records and others indicate that sand and gravel beds are most common below a level of about 655 feet above sea level. Sand and gravel beds as thick as 200 to 220 feet are likely to occur in the deepest portion of the Ancient Rock Valley in eastern Lee County. No accurate geologic records are available in the areas where thickest deep sand and gravel is expected. No high-capacity gravel wells have been drilled in the buried Rock Valley of eastern Lee County, but more than 100 square miles of this area may be suitable for major well programs.

Microscopic study of all available drill cuttings from deep sand and gravel in the buried Rock (Paw Paw) Valley of eastern Lee County indicates that a large percentage of the sand-size grains are frosted subrounded quartz with some orange staining. Pink quartz and dark heavy minerals are scarce. These facts indicate that the St. Peter was the source of most of the sand in the deep fill of the Ancient Rock Valley in Lee County. The gravel consists mostly of angular fragments of Galena-Platteville dolomite. Few dolomite grains are as small as 60 mesh (0.0097 inches), which suggests local origin for most of the gravel. Gravels of crystalline rock are not abundant.

Deposits in the buried Mississippi Valley of southwestern Whiteside County.—The ancient course of the Mississippi, from about southwest of Albany to the Henry County line in T. 19 N., R. 5 E., has long been suspected to contain an extensive deposit of water-bearing sand and gravel, but no water well or test is known in that part of the buried valley believed most promising. A test hole and well drilled in 1952-53 at Erie penetrated 176 feet of sand and fine gravel over dolomite bedrock.* Horberg (1950a) believes that the main buried bedrock valley lies one to two miles north of Erie. New information from Whiteside County does not change this location. No borings in Whiteside County are known to have been drilled to bedrock deeper than about 400 feet above sea level and, therefore, the lower 100 feet of drift remains unexplored in this area. The possibilities appear good that the deep channel of the Ancient Mississippi is partly or largely filled with permeable sand or gravel.

The sand and gravel beds in the deep bedrock valley in southwestern Whiteside County are mantled largely by water-bearing sand of the Green River lowlands, a geologic condition indicating a promising groundwater supply. This shallow sand accounts in part for the scarcity of deeper drilling in the bedrock valley. Sources suitable for moderate to large supplies of industrial groundwater lie high above the promising deeper beds. Opportunities for groundwater recharge of the deep deposits by surface infiltration from the Green and Rock rivers and from local rainfall are excellent because of the absence of a thick, tight barrier such as is found over the buried Rock Valley in eastern Lee County.

About 70 square miles in southwestern Whiteside County appear to be favorable for the occurrence of deep sand and gravel over the flanks or middle of the old Mississippi Valley. A much broader area in this

* The State Water Survey reports that Erie well 2 has a specific capacity of approximately 80 gallons per minute per foot of drawdown at 964 gallons per minute. Static water level: 17 feet.


WHITESIDE COUNTY
Scale
0 1 2 miles
R.3E.
R.4E.
R.5E.
R.6E.
R.7E.
T. 22 N.
T. 21 N.
T. 20 N.
T. 19 N.
AREA 1
AREA 2
AREA 3
Sterling
Rock Falls
Tampico
Lyndon
Prophetstown
Morrison
Erie
Fulton
Albany
MISSISSIPPI
RIVER
ROCK
RIVER
Township showing section numbers
6 5 4 3 2 1
7 8 9 10 11 12
18 17 16 15 14 13
19 20 21 22 23 24
30 29 28 27 26 25
31 32 33 34 35 36

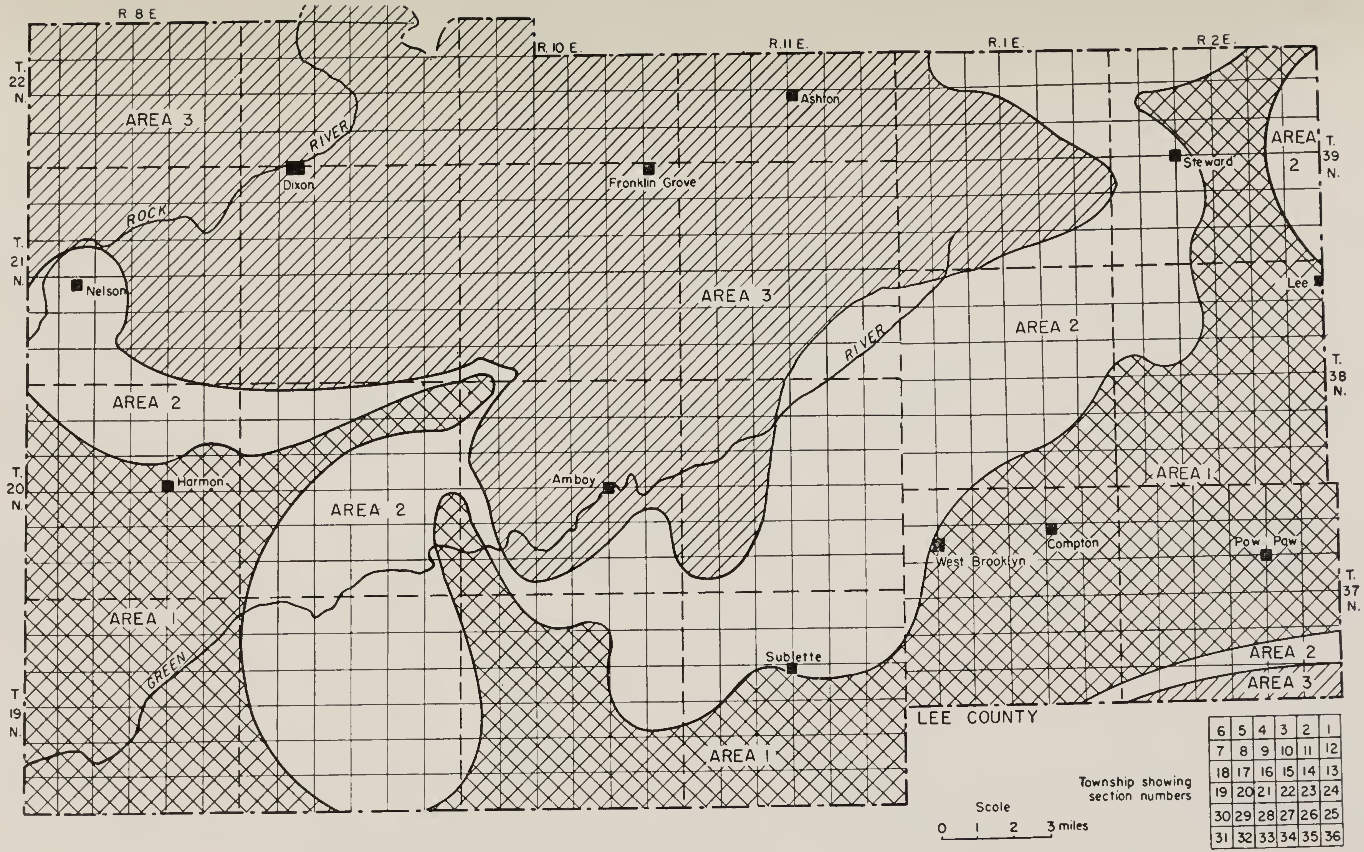


FIG. 5.—Groundwater possibilities in sand and gravel beds above bedrock in Lee and Whiteside counties. *Area 1.*—Good to excellent possibilities for industrial or municipal supplies. Sources locally more than 300 feet deep in highland areas. *Area 2.*—Some possibility for industrial or municipal supplies. Fair to good possibilities for private supplies. *Area 3.*—Generally poor possibilities for any supplies from drilled wells in sand and gravel. Area for dug wells or deeper wells drilled in bedrock.

region shows promise of attractive shallow sands and gravels (see section on Green River lowlands).

Drill cuttings from the Eclipse Lawn Mower well 2 at Prophetstown, NE¼ NE¼ sec. 5, T. 19 N., R. 5 E., Whiteside Co., indicate the type of material associated with the low bedrock elevations of the Ancient Mississippi Valley in southeastern Whiteside County. The following log is based on drill cuttings and interpretation of the driller's log.

	Thickness feet	*Depth feet*
Pleistocene series		
Soil and clay, yellow	6	6
Sand, yellow, dry	24	30
Sand, yellow, coarse, water-bearing	20	50
Clay, buffish pink, sandy, calcareous (till?)	15	65
Sand, gray, fine, with clay balls	15	80
Sand, light gray, fine to medium, clean	5	85
Sand, buff, silty, with organic fragments	15	100
Sand, yellow to brown, some gravel, silty	15	115
Sand, pinkish brown, medium to coarse, clean	70	185
No record	3	188
Silurian system		
Niagaran dolomite	below	

Construction: 65 feet of 16-inch casing; 120 feet of 10-inch casing; 40 feet of 8-inch screen. Drillers tested the well at 600 gallons per minute, but sand caused abandonment of the well.

The upper 50 feet of this well appears to penetrate the outwash sand so widespread over the Green River lowlands. The lower 120 feet penetrates the pinkish sands that appear typical of Mississippi Valley deposits.

Deposits in the Mississippi Valley of western Whiteside County.—There can be little doubt that sand and gravel deposits beneath the flats of the Mississippi Valley in northwestern Whiteside County are one of the most promising sources of shallow groundwater in Illinois, but the groundwater resources of the valley fill have been little exploited. Regional information shows that the ancient course of the Mississippi generally coincides with the present bottomlands of the Mississippi River from Dubuque, Iowa, south to the Albany area in Whiteside County.

Fulton city well 3 (SW¼ sec. 26, T. 22 N., R. 3 E., Whiteside Co.), drilled in 1931 to a total depth of 1943 feet, penetrated 133 feet of Mt. Simon sandstone. No samples of drill cuttings are available for the upper 100 feet of this well. However, the lower 90 feet of valley fill shows 70 feet of sand and fine gravel over Maquoketa shale. The bedrock elevation at this site is 410 feet. The bedrock surface is probably about 100 to 130 feet lower a mile or so southeast of this well. The lowest channel of the partially buried Mississippi Valley in western Whiteside County is almost certainly less than 300 feet above sea level. About 50 miles upstream from Whiteside County the Dubuque Star Brewing Company well (NW¼ sec. 30, T. 89 N., R. 3 E., Dubuque Co., Iowa), drilled in 1933, encountered bedrock at an elevation of 285 feet above sea level. This is the lowest bedrock elevation known in the Upper Mississippi Valley. Samples of drill cuttings from the Dubuque well show at least 328 feet of water-bearing sand and gravel. This is good evidence of the groundwater possibilities in sand and gravel in the same valley in Whiteside County.

The Mississippi Valley between Savanna, Carroll Co., and Fulton, Whiteside Co., is 4 to 7 miles wide, whereas the valley north of Savanna is generally less than 4 miles wide. Horberg (1950a) suggests that the widening of the valley south of Savanna may be due to crowding of the river against the west valley wall by Illinoian ice. Such an event might have buried the deep bedrock channel on the east side of the present bottomlands under tight till. Although later erosion probably removed all or most of the till deposits that may have lain in the valley, the possibility remains that some Illinoian till may be found over the lower parts of the bedrock valley on the east side of the present bottoms. If till is not present, the valley fill is likely to be almost entirely sand and gravel, possibly with thicknesses of as much as 325 feet.

Microscopic studies of sands in the Upper Mississippi Valley at Dubuque (Star Brew-

ing Company well) indicate that these deposits are similar in character and appearance to the deep deposits encountered at Erie, Whiteside Co., in the ancient valley of the Mississippi southeast of its present course. The sands are generally more than 95 percent quartz, with marked iron staining which gives a pinkish-orange cast. The percentage of dark heavy minerals appears markedly higher in these sands of the Mississippi Valley than in those of the ancient or present Rock Valley. Dolomite is rare except in the gravels.

Shallow Sand and Gravel Beds in the Green River Lowlands

The largest sandy lowland in Illinois is the area lying principally between the Rock and Green rivers. The area comprises parts of Whiteside, Henry, Bureau, and Lee counties. More than one-third of the 1436 square miles in Lee and Whiteside counties is sandy lowland. About 540 square miles of these counties contain shallow sand and gravel beds. In at least 500 square miles the shallow sands are believed thick enough to permit well construction with drive points. In more than half the area the shallow deposits of sand and gravel in the lowlands are probably suitable for industrial or municipal wells (fig. 5). Few large areas in Illinois offer so much opportunity for the development of major supplies of groundwater with wells generally less than 100 feet deep for irrigation projects and industrial uses. The occurrence of shallow sand throughout the area is discussed under "Summary of Groundwater Possibilities by Townships."

Some of the sandy lowlands are simple valley bottomlands—for example, the flood plain of the present Mississippi in northwestern Whiteside County—but most of the lowland area cannot be classed as modern bottomland because it has no relation to existing streams. This vast sand plain is commonly known as the Green River lowlands, although the plain extends several miles north of the Rock River in south-central Whiteside County. In Lee County the lowland splits into two fingers, one of which follows the Green River through central and northeastern Lee County, and the other, a more confined lowland, follows the Rock River toward Dixon in northwestern Lee County. The lowlands are bounded by highlands of tight glacial till—on the south by Shelbyville and Bloomington till, on the north by Shelbyville till, and locally by Illinoian till.

Deposits of the Green River lowlands.—The Green River sand plain was a lowland before glaciation. Bedrock elevations above sea level are over 750 feet in the uplands but beneath the lowlands are locally below 600 feet and generally below 650 feet. The region was a natural one for the accumulation of sand and gravel throughout glacial time because it remained relatively low except in the extreme southeastern part where the Bloomington moraine was built.

Deep drilling in the sand plain has been widely scattered because water wells for farm supplies can easily be constructed by drive points. Little accurate geologic information is obtainable from this type of drilling. Where bedrock is higher than about 575 feet above sea level (fig. 4), most or all of the material above bedrock is likely to be sand and gravel. Where bedrock is lower, the lowlands may contain scattered remnants of tight clay till below shallow sand and gravel. The abundance and location of buried clayey deposits is unknown. It is certain that at two or more times during the Pleistocene, glaciers occupied the lowland country. Illinoian and Green River glacial till lies on the flanks of the Green River lowlands, and it must be presumed that clay till from these ice invasions was deposited in the lowlands. The extent to which the tight clay till has since been eroded is not known.

Where bedrock elevations are below about 655 feet in the lowlands of Lee and Whiteside counties, sand and gravel deposits are probably of pre-Illinoian age. However, most of the sand and gravel now occupying the Green River lowlands is certainly much younger than the sands of the Ancient Rock Valley. Available geologic data from drilling in Bloomington till in

southeastern Lee County indicate that sands and gravels below the thick till are associated with the old Rock Valley rather than with widespread shallow sands in the Green River lowlands.

The thickness of the sands and gravels of the Green River lowlands is largely controlled by the unduluations of the buried bedrock surface—thin sand where the rock is high, thick sand where the rock is low. The sand and gravel that occurs over the Ancient Mississippi Valley in southeastern Whiteside County is very thick (325 to 340 feet). The lower 100 to 150 feet of this deposit is related to the old buried valley rather than to the sand plain of the Green River lowlands.

The permeable water-bearing beds in the lowlands are largely medium-to-coarse sand and fine gravel. Thin, apparently discontinuous silt streaks are known at many locations, but the sand and gravel beds themselves are remarkably free of clay, silt, and fine sand.

Recent changes in the Green River lowlands.—The surface of the sand plain is marked by sand dunes that were developed recently. Dune sand is believed to cover gravel rubble bars in south-central Tampico Township, Whiteside Co., where a string of dune-like mounds suggests a bar built in a sand-choked flooded plain. It is not known how many of the dune-like mounds of the Green River lowlands have gravel cores.

Aerial photographs of Lee and Whiteside counties reveal that the Rock River southwest of Dixon has meandered across the sand plain through a belt 2 to 5 miles wide. The meander scars are not easily observed on the land surface, but photographs clearly show variations in soil color and soil moisture caused by small variations in texture and drainage. In areas where the bedrock is higher than about 600 feet above sea level, the entire thickness of the sand plain may have been scoured away by the Rock River, then replaced by alluvium.

Water-yielding characteristics and well construction.—In the few places in the Green River lowlands where shallow high-capacity wells have been drilled, the sands and gravels have shown high permeability. They probably will have favorable recharge characteristics because of good lateral and vertical connection to streams, such as the Rock and Green rivers, and to the land surface for percolation of rainfall. Groundwater throughout the sand plain appears to occur under water-table or no-pressure conditions.

An irrigation project in the sand plain east of Rock Falls, sec. 26, T. 21 N., R. 7 E., Whiteside Co., obtains a major supply of groundwater from a series of screened drive points about 60 feet deep. The water table is high, so these wells are successfully pumped by suction through a manifold. Where suitable, this is an economical method of obtaining industrial groundwater. In many parts of the Green River lowlands, even more water could be obtained from shallow sand and gravel by using large-diameter screened wells and deep-well pumps.

Although most farms in the Green River lowlands obtain water supplies from driven sand points, scattered wells from which geologic information can be obtained have been drilled. A typical drilled well is located on the Grobe farm, Montmorency Township (T. 20 N., R. 7 E., Whiteside Co.). The driller's log of this well follows.

	Thickness feet	*Depth feet*
Pleistocene series		
Soil and fine wind-blown sand	4	4
Sand, gray, loose	40	44
Gravel, loose, water-bearing	6	50

This well is equipped with 50 feet of 6-inch iron pipe. No screen was set. Although screens are ordinarily desirable, they are not necessary in places such as this where a coarse sand and gravel formation does not heave under ordinary domestic pumping and where the water-yielding capacity of the formation greatly exceeds the demand on the well. Screens with carefully selected slot openings not only prevent heaving and pumping of sand but provide the best well construction. They allow a maximum yield with minimum drawdown of water level during pumping.

The first sand and gravel well owned by the Northern Illinois Water Corporation at Sterling-Rock Falls was constructed in 1953 by the Kelly Well Company. It was located about 1½ miles south of the Rock River in Rock Falls (NE¼ SW¼ sec. 33, T. 21 N., R. 7 E., Whiteside Co.). The well site is in that portion of the lowland which was channeled by the Rock River, but whether a significant part of the original outwash deposit of sand and gravel has been replaced by river alluvium is unknown. The geologic record that follows is based on drill cuttings from the test hole for this well, no. 1-53.

	Thickness feet	*Depth feet*
Pleistocene series		
Sand, yellow, medium, oxidized, clean, noncalcareous	5	5
Gravel and sand, yellow, slightly silty, calcareous	5	10
Gravel and sand, cleaner, scattered clay balls	5	15
Sand, yellow, coarse, sorted, clean, calcareous	5	20
Gravel and sand, yellow, clean, poor sorting, calcareous	10	30
Sand and fine gravel, with noncalcareous brown silt streaks	10	40
Sand, medium, clean, with gravel streaks	15	55
Clay, buff, slightly pink, calcareous with gravel below	5	60
Gravel, coarse, clean, with clayey streaks	12	72
Silurian system		
Niagaran dolomite	4+	76

This well is constructed of 30-inch diameter concrete sections to bedrock (72 feet), with precast slotted concrete below a depth of about 40 feet, and a poured gravel envelope. Early tests indicate that the well should have a specific capacity of at least 75 gallons per minute per foot of drawdown, allowing a possible safe yield of more than 1000 gallons per minute.

BEDROCK FORMATIONS

Pennsylvanian Beds

Occurrence.—Formations of the Pennsylvanian system are the youngest bedrock known to occur below the glacial drift in the area. They are found only in southwestern Lee County, Ts. 19 and 20 N., Rs. 9 and 10 E. (figs. 3 and 6). These beds are largely shale, with thin strata of limestone, sandstone, and coal. They lie mostly on Niagaran dolomite and Maquoketa shale, except in a small area in T. 20 N., R. 9 E., where they appear to lie on Galena-Platteville dolomite. They probably are as much as about 100 feet thick in the vicinity of secs. 2, 3, 4, and 10, T. 19 N., R. 9 E., Lee Co.

Water-yielding characteristics.—Beds of the Pennsylvanian system are not as a rule worth exploring for sources of domestic or larger water supplies. Most of the limestones contain few water-yielding cracks. The sandstones are generally tight and discontinuous, with poor water yields. Water in Pennsylvanian sandstones and limestone cracks is commonly of undesirable quality. Usable water is locally obtained near the top of the bedrock where the beds have been flushed out and recharged with water from the overlying glacial drift. The State Geological Survey has no record of wells in Lee County constructed in any beds of the Pennsylvanian system.

Drilling characteristics and well construction.—Pennsylvanian beds are not difficult to penetrate with cable-tool drills. Many of the shale beds are firm; others are weak and cave into open bore holes. The so-called "underclays" swell and disintegrate along the walls of an open hole. Water wells that are constructed in beds below the Pennsylvanian are always cased through the Pennsylvanian section to avoid bridging and to prevent any water seepage from Pennsylvanian beds.

Niagaran-Alexandrian Dolomite (Silurian)

Occurrence.—Formations of Silurian age in Lee and Whiteside counties are the Niagaran-Alexandrian dolomites, which are distinguishable but considered here as one unit. These beds lie directly beneath the glacial drift in most of Whiteside County, although they are missing in T. 22 N., Rs. 3 and 7 E., and adjacent areas. Niagaran-Alexandrian dolomites generally are missing in Lee County except in the extreme southwestern part where they underlie glacial drift and Pennsylvanian beds (fig. 6).


WHITESIDE COUNTY
Scale
0 1 2 miles
R. 3 E.
R. 4 E.
R. 5 E.
R. 6 E.
R. 7 E.
T. 22 N.
T. 21 N.
T. 20 N.
T. 19 N.
Galena-Platteville dolomite
Maquoketo shale
Local, thin dolomite
Silurion dolomite
Silurian dolomite
Silurian dolomite
Maquoketa shale
Fulton
MISSISSIPPI RIVER
Albany
Morrison
Sterling
Rock Falls
ROCK RIVER
Lyndon
Prophetstown
Tampico
Erie
Township showing section numbers
6 5 4 3 2 1
7 8 9 10 11 12
18 17 16 15 14 13
19 20 21 22 23 24
30 29 28 27 26 25
31 32 33 34 35 36

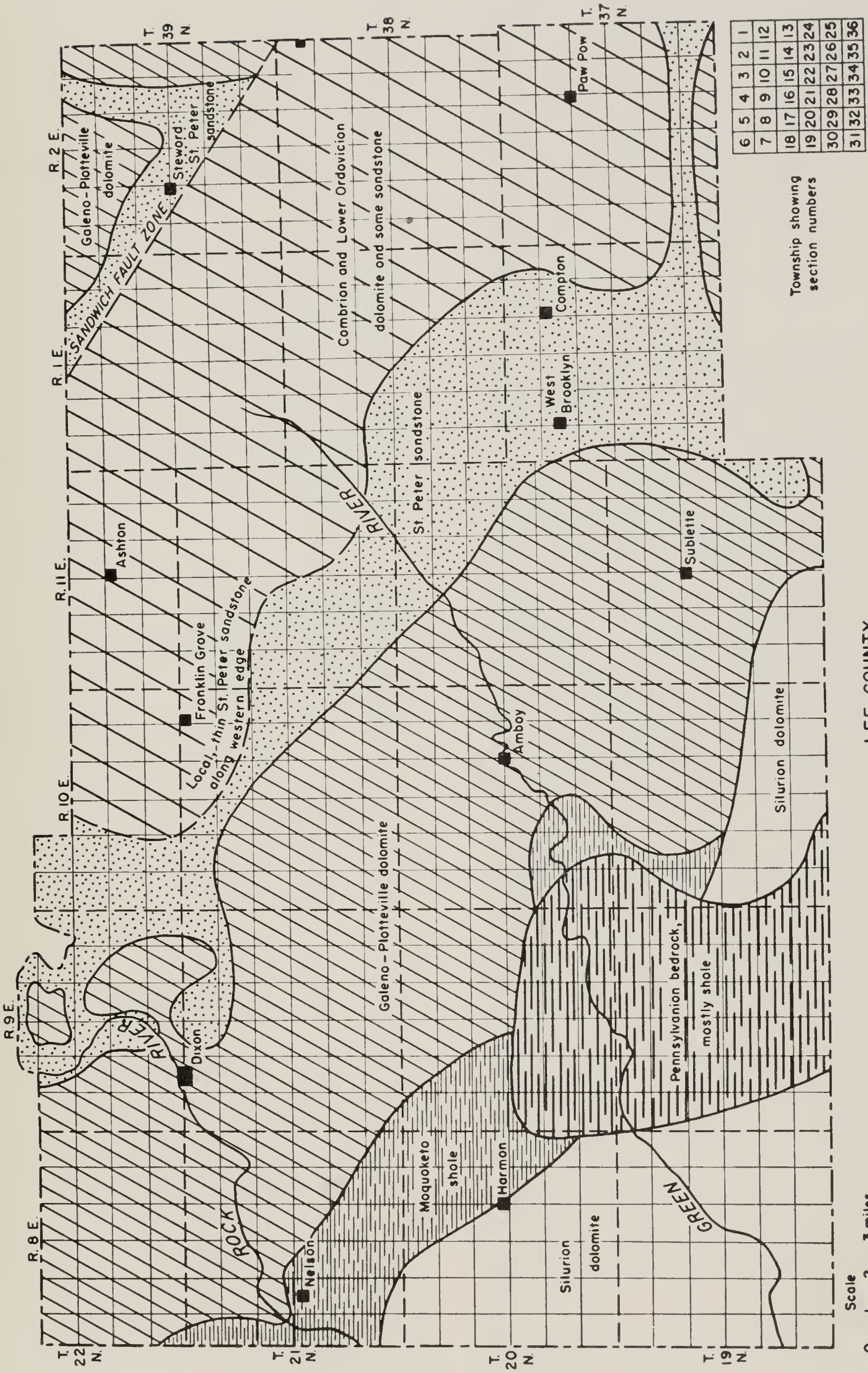


FIG. 6.—Geology of the bedrock in Lee and Whiteside counties.

Wherever they occur in this region they rest on Maquoketa shale and shaly dolomite. These dolomites range in thickness from zero, along the feather edge, to an estimated 450 feet near Tampico, T. 19 N., R. 6 E., Whiteside Co.

Water-yielding characteristics.—Scores of water wells in Whiteside County and some in southwestern Lee County tap groundwater from open cracks in Niagaran-Alexandrian dolomite. Water-bearing cracks are particularly common in the upper 50 to 100 feet of rock. They are rarely too tight to yield groundwater to domestic and farm wells. Along their feather edge, in northeastern and northwestern Whiteside County and southwestern Lee County, the dolomites are too thin to be developed. In that case, wells are usually drilled to dolomite beds in the underlying Maquoketa formation or to deeper dolomite or sandstone. In T. 19 N., R. 9 E., Lee Co., and in nearby areas, the Niagaran-Alexandrian dolomites are covered by Pennsylvanian shales. In this area it may be necessary to consider the possibility of poor water quality from the Niagaran-Alexandrian dolomites, because the open cracks may be charged with mineralized groundwater from the overlying shales.

Drilling characteristics and well construction.—Most drillers recognize the Niagaran-Alexandrian dolomites by their light gray color and generally abundant cracks and openings. These dolomites contain hard chert fragments in many places. Some have thin shaly zones in the lower part, but no serious difficulties in drilling with a cable-tool rig are known. It is occasionally difficult to maintain vertical hole where the bit strikes a steeply inclined crack or steep bottom surface of a large opening. Drilling with rotary tools would likely be difficult locally because of the problem of maintaining mud circulation in zones containing abundant cracks.

Wells that tap water from open cracks in the Niagaran-Alexandrian beds can be left unlined. This cannot be done, however, in areas where the glacial drift is thinner than 30 to 50 feet, particularly with high-capacity wells, because in those places there is danger of pollution from these dolomites. Where pollution is a hazard, lining is often set and grouted to the top of the Galena-Platteville dolomite. Polluted Niagaran-Alexandrian groundwater is a hazard, particularly near Sterling–Rock Falls, north of Morrison, northeastern T. 22 N., R. 4 E., and in the vicinity of Albany and Fulton, Whiteside Co.

An example of a well constructed in Niagaran-Alexandrian dolomite is that located on the Hammer farm north of Morrison, Whiteside Co., sec. 12, T. 22 N., R. 4 E. This well penetrates 42 feet of dolomite and has a total depth of 63 feet, with 6-inch casing set to a depth of 21 feet. Driller: John Eckel, 1939. The geologic record that follows is based on an interpretation of the driller's log.

	Thickness feet	*Depth feet*
Pleistocene series		
Humus, black	3	3
Till, yellow, pebbly, clayey	18	21
Silurian system		
Niagaran dolomite	42	63

Maquoketa Shale and Dolomite (Ordovician)

Occurrence.—Maquoketa shale in this area lies below the Alexandrian dolomite and above the Galena dolomite, in the normal geologic sequence of formations. In parts of T. 22 N., Rs. 3 and 7 E., and neighboring areas in Whiteside Co., it lies directly below glacial drift in a belt extending southeastward from Nelson (fig. 6). In the extreme northeast corner of Whiteside County and in all of Lee County lying northeast of Nelson, Amboy, and Sublette, the Maquoketa formation is missing.

Except along its feather edge the Maquoketa formation is generally 150 to 200 feet thick; it is possibly more than 275 feet thick near Lyndon, Whiteside Co.

The Maquoketa formation is commonly a bluish-gray shale, although some of it is greenish gray. The formation also includes one or more zones of dark dolomite and shaly dolomite.

Water-yielding characteristics.—In some places where Maquoketa shale directly un-

derlies the glacial drift, farm wells obtain water from open cracks in the dolomite zones of the Maquoketa formation. In general, however, the Maquoketa beds are considered non-water-yielding where they are between the Alexandrian and Galena dolomites. The shale portions of the Maquoketa formations are too tight to allow significant movement of groundwater; they are also too weak and soft to contain open cracks.

Drilling characteristics and well construction.—Nearly all water wells that tap formations lying below the Maquoketa shale are cased through the entire Maquoketa formation. A number of shale zones in the Maquoketa formation are too weak to maintain an open hole without lining. Other zones in the formation are firm enough to permit open-hole construction, but it is generally economical to line the entire formation. It is a common practice in St. Peter wells to change hole diameter a few feet below the base of the Maquoketa formation and to set casing on this shoulder before drilling deeper. This permits a clean hole without interference from caving shale. Drillers watch for the top of the Galena dolomite with this construction plan in mind. Where the bottom part of the Maquoketa formation is dolomite, the break between it and the Galena formation generally can be recognized by an increase in hardness and a change from dark dolomite above to lighter dolomite below.

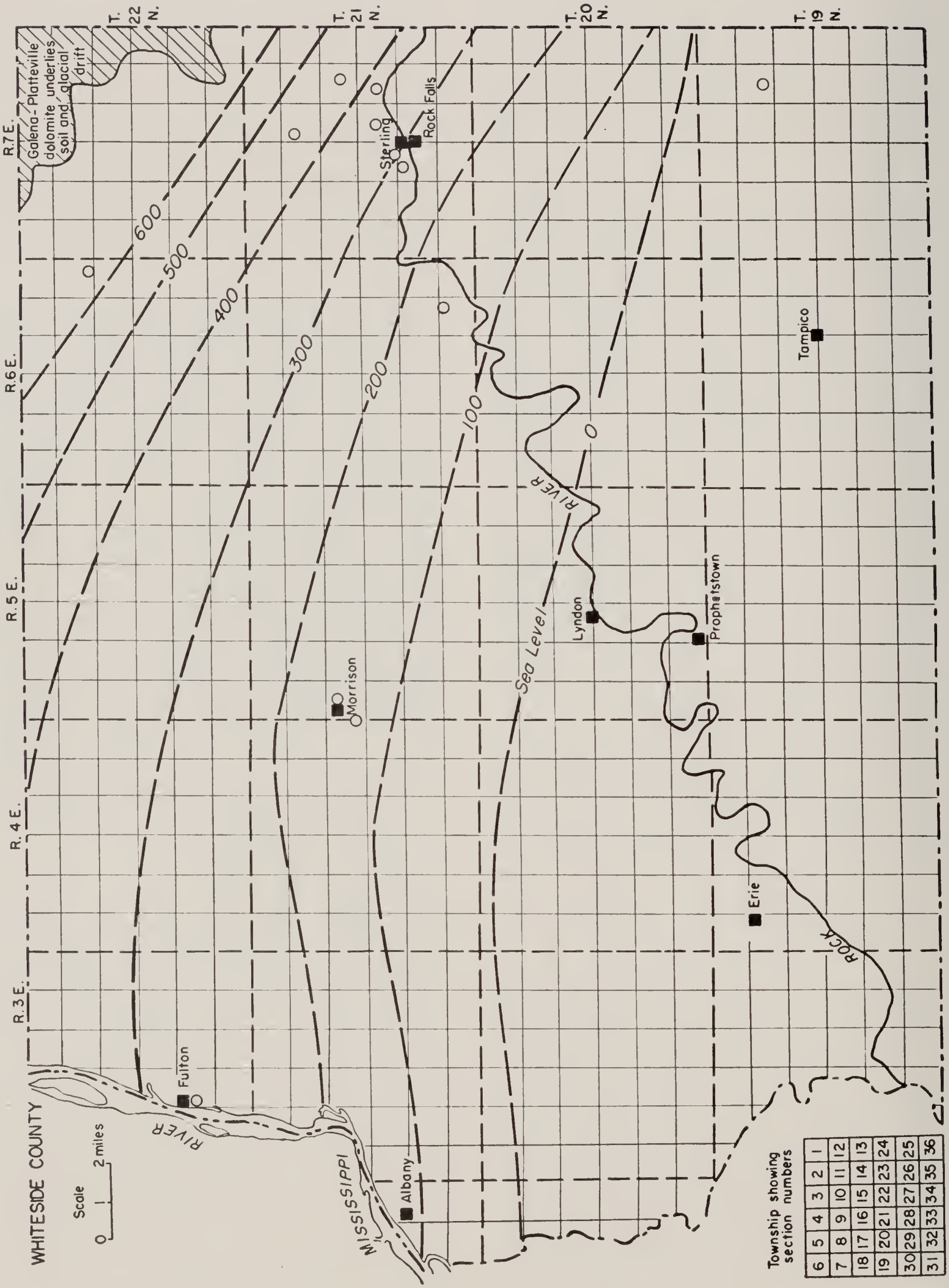
Galena-Platteville Dolomite (Ordovician)

Occurrence.—The Galena-Platteville dolomite occurs throughout Whiteside County and in Lee County southwest of Dixon, Amboy, and Sublette (fig. 6). Structure contours on the Galena-Platteville dolomite are shown in figure 7. In general these beds lie beneath Maquoketa shale, but they lie directly beneath glacial drift in the extreme northwest corner of Whiteside County and in a wide belt extending southeastward from the northwest corner of Lee County through Sublette in southern Lee County. The average thickness of the Galena-Platteville beds is about 375 feet.

Galena-Platteville dolomite is generally buffish gray—much lighter than the dolomite beds of the overlying Maquoketa formation. At most locations the Galena dolomite is separated from the Platteville dolomite below by a few feet of dark, locally greenish, shale. Most of the Galena formation contains numerous hard chert fragments. The Platteville beds generally contain abundant specks of pyrite, an iron sulphide mineral. The base of the Platteville is marked by a change to the greenish shale and sandstone of the Glenwood formation.

Water-yielding characteristics. — Farm supplies of groundwater are obtained from open cracks in the Galena-Platteville beds at many places in Lee and Whiteside counties. The beds are suitable for industrial wells only at scattered locations. Where it lies beneath Maquoketa shale, the dolomite is not as favorable a source of groundwater as where it lies directly beneath glacial drift. However, it yields some water to many deep wells that are designed to tap the St. Peter or the Galesville sandstones. Many of the cracks and cavernous openings found in the Galena-Platteville dolomite are partially filled with silt and clay. These crevice fillings, plus the fact that poor-quality water is frequently found, make the Galena-Platteville beds generally unattractive for groundwater supplies except where they are directly beneath the glacial drift.

Drilling characteristics and well construction.—Cable-tool drilling in the Galena-Platteville beds is not difficult. Maintaining straight hole is normally easier than in the Niagaran dolomite because many of the openings are partially filled with sediment and there are fewer smooth, sloping surfaces to deflect the tools. Except where it is necessary to shut out poor-quality water, wells penetrating the Galena-Platteville dolomite can be left uncased. Some wells that tap the St. Peter sandstone pump silty water, perhaps as a result of caving from crevices in the Galena-Platteville dolomite. The water usually clears up in a few weeks when the openings near the well clean themselves of sediment.


WHITESIDE COUNTY
Scale
0 1 2 miles
Galena-Platteville dolomite underlies soil and glacial drift
R.7E.
R.6E.
R.5E.
R.4E.
R.3E.
T. 22 N.
T. 21 N.
T. 20 N.
T. 19 N.
600
500
400
300
200
100
0
Sea Level
Sterling
Rock Falls
Morrison
Fulton
Albany
Lyndon
Prophetstown
Tampico
Erie
ROCK RIVER
MISSISSIPPI RIVER
Township showing section numbers
6 5 4 3 2 1
7 8 9 10 11 12
18 17 16 15 14 13
19 20 21 22 23 24
30 29 28 27 26 25
31 32 33 34 35 36

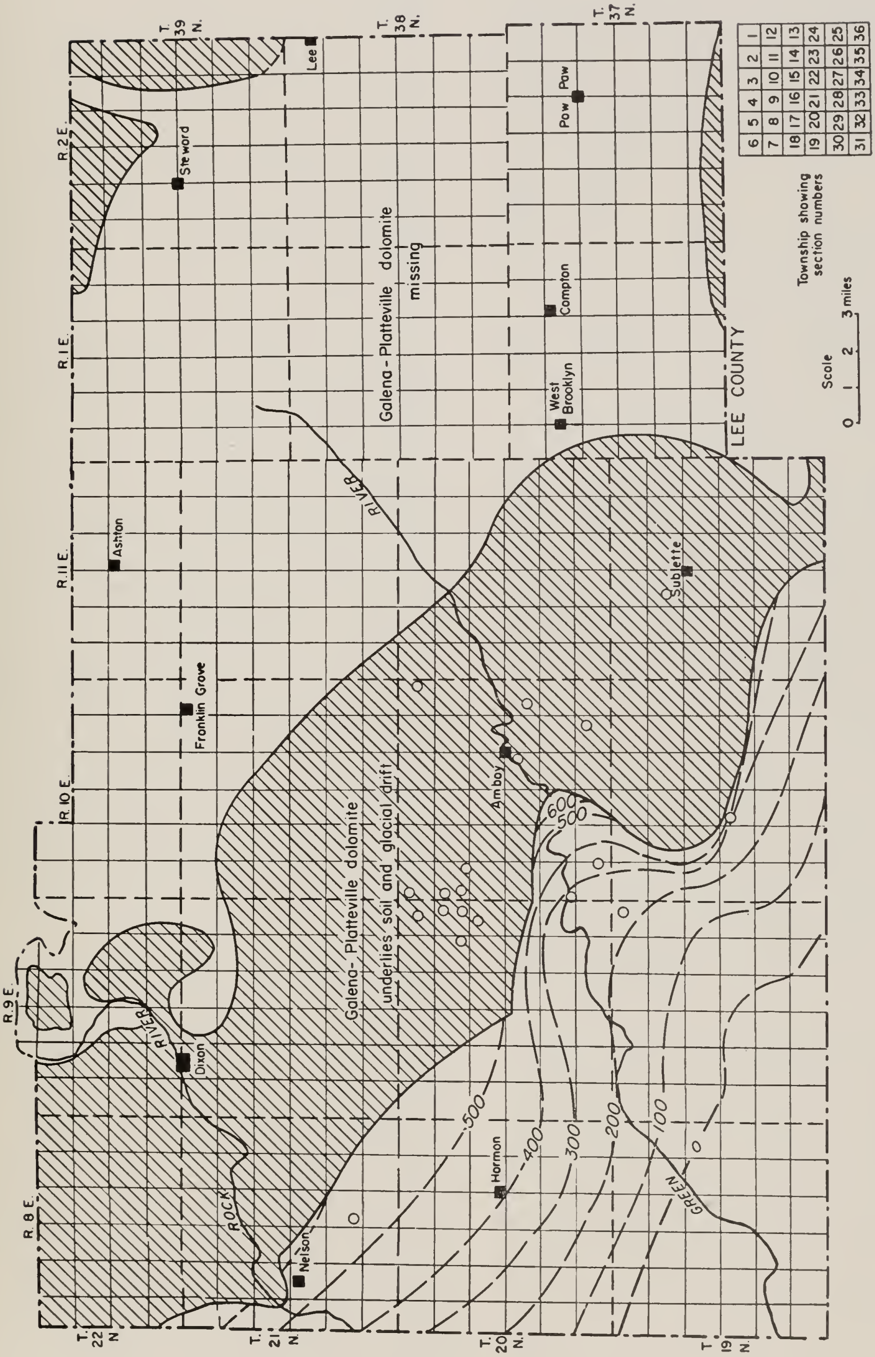


FIG. 7.—Structure contour maps of Galena-Platteville dolomite in Lee and Whiteside counties. Contours show approximate elevation of the top of the Galena-Platteville dolomite in feet above sea level. Circles indicate wells used as control points.

An example of a well constructed in the Galena-Platteville formation is one at Sterling State Police Headquarters near the center of sec. 14, T. 21 N., R. 7 E., Whiteside Co. This well penetrates about 195 feet of Galena dolomite and has a total depth of 475 feet, with 301 feet of 6-inch casing. Study by W. H. Bierschenk.

	Thickness feet	*Depth feet*
Pleistocene series		
Till, yellowish orange, clayey	30	30
Silurian system		
Alexandrian dolomite	50	80
Ordovician system		
Maquoketa shale	200	280
Galena dolomite	195	475

Glenwood–St. Peter Sandstone (Ordovician)

Occurrence.—The Glenwood–St. Peter sandstone* probably occurs throughout Whiteside County and in Lee County west of Compton and Franklin Grove. The unit generally lies below the Platteville dolomite but lies beneath glacial drift in a broad belt through central Lee County (fig. 6). In southern Whiteside County the top water-bearing zones of the St. Peter formation lie about 400 feet below sea level (about 1050 feet deep at Tampico, fig. 8). The sandstone is exposed on the surface at numerous places northeast of Dixon, Lee Co., and locally elsewhere. The St. Peter formation varies greatly in thickness, owing partly to gradual thickening or thinning from area to area and partly to local unevenness of the bottom of the sandstone because it was deposited on an irregular surface. It is generally between 100 and 150 feet thick in Whiteside County, except in the northeastern part—from Sterling north and from Morrison east, where it is commonly only 50 to 100 feet thick. At the Northwestern Steel and Wire Company in Sterling, a well drilled in 1952 encountered only 45 feet of St. Peter, 720 to 765 feet deep, according to samples provided by the Allabaugh Well Company.

In Lee County the thickness of the Glenwood–St. Peter sandstone ranges from about 100 feet at Dixon to probably more than 250 feet at the eastern edge of the county; there is a gradual thickening from west to east. It is more than 300 feet thick at DeKalb, DeKalb Co.

The top of the Glenwood beds, base of the Platteville dolomite, is commonly recognized in Lee and Whiteside counties by a change to greenish shale and a decrease in drilling time. The shale is normally about 8 feet thick. It is underlain by slightly reddish sandstone and streaks of sandy dolomite —the top of the St. Peter sandstone. The sandstone below is grayish white with some hard, cemented zones and some very soft zones. Firmness depends largely on the sorting of the quartz grains and the amount of carbonate cementing material. The St. Peter sandstone in Lee and Whiteside counties normally lies on Shakopee dolomite, although elsewhere in northern Illinois, where unusually great thicknesses of St. Peter sandstone are found, it may lie on various formations down to the Franconia. This is due in part to deep valleys cut into the formations below the St. Peter that were later filled with St. Peter sands and in part to pre–St. Peter deformation of the underlying formations. Drillers as a rule find a reddish shale 2 to 10 feet thick at the bottom of the sandstone and solid dolomite below the shale bed.

Water-yielding characteristics. — For many years the St. Peter was reputed to be a very favorable artesian sandstone throughout northern Illinois. This reputation was based largely on the high water pressure encountered in the formation during the first few decades of its development, prior to 1900. However, its permeability normally ranks far below the Galesville sandstone and below portions of the Mt. Simon sandstone. The highly permeable zones in the St. Peter are not continuous laterally but grade and interfinger with tighter zones where movement of groundwater is restricted, whereas the permeable zones in the Galesville, although they may be no thicker than the St. Peter in a given well,

* To geologists there is a notable difference between the shaly Glenwood formation above and the St. Peter sandstone below it. Because both formations may contain water-yielding zones, they are generally considered here as one unit, although reference is made here and there to the individual formations.

persist over large areas. The St. Peter sandstone in Lee and Whiteside counties is more permeable and generally a more favorable source of groundwater than it is in northeastern Illinois.

Despite its shortcomings, the St. Peter sandstone is a valuable source of groundwater in Lee and Whiteside counties, yielding to several industrial wells in the Sterling–Rock Falls area and elsewhere and to small private wells in central Lee County where the sandstone lies beneath thin glacial drift.

Drilling characteristics and well construction.—More difficulty has been encountered in cable-tool drilling in the St. Peter than in any other formation in northern Illinois. The sandstone is notorious among drillers for its tendency to cave during drilling operations; there are dozens of places where spalling sand and cave-ins have caused the loss of tools. The St. Peter formation is made up of soft zones interlayered with firm, partly cemented zones. Where a hole can enlarge itself in a soft sandy or shaly zone during drilling operations, there is great danger of the hole's bridging by failure of the overlying firm bed or sandstone. If bridging takes place when the bit is deep in the hole, the recovery of tools, particularly in small borings, may be impossible. Short drilling runs, thorough cleaning of the drill hole, hole reduction at the base of the formation, and casing the sandstone all help the success of wells tapping formations below the St. Peter. Wells tapping St. Peter water are commonly designed to penetrate the entire thickness of the sandstone and at least 25 to 50 feet of beds below it. This "rat hole" at the base provides a space for the collection of caved material during the life of the well. It is not good engineering practice to set pump bowls opposite the St. Peter formation unless the sandstone is lined, because turbulent water around the pump intakes and downward flow of water toward the intakes can cause spalling of sand near and above the pump setting. If practical, a shallower pump setting opposite the Galena-Platteville formation is desirable.

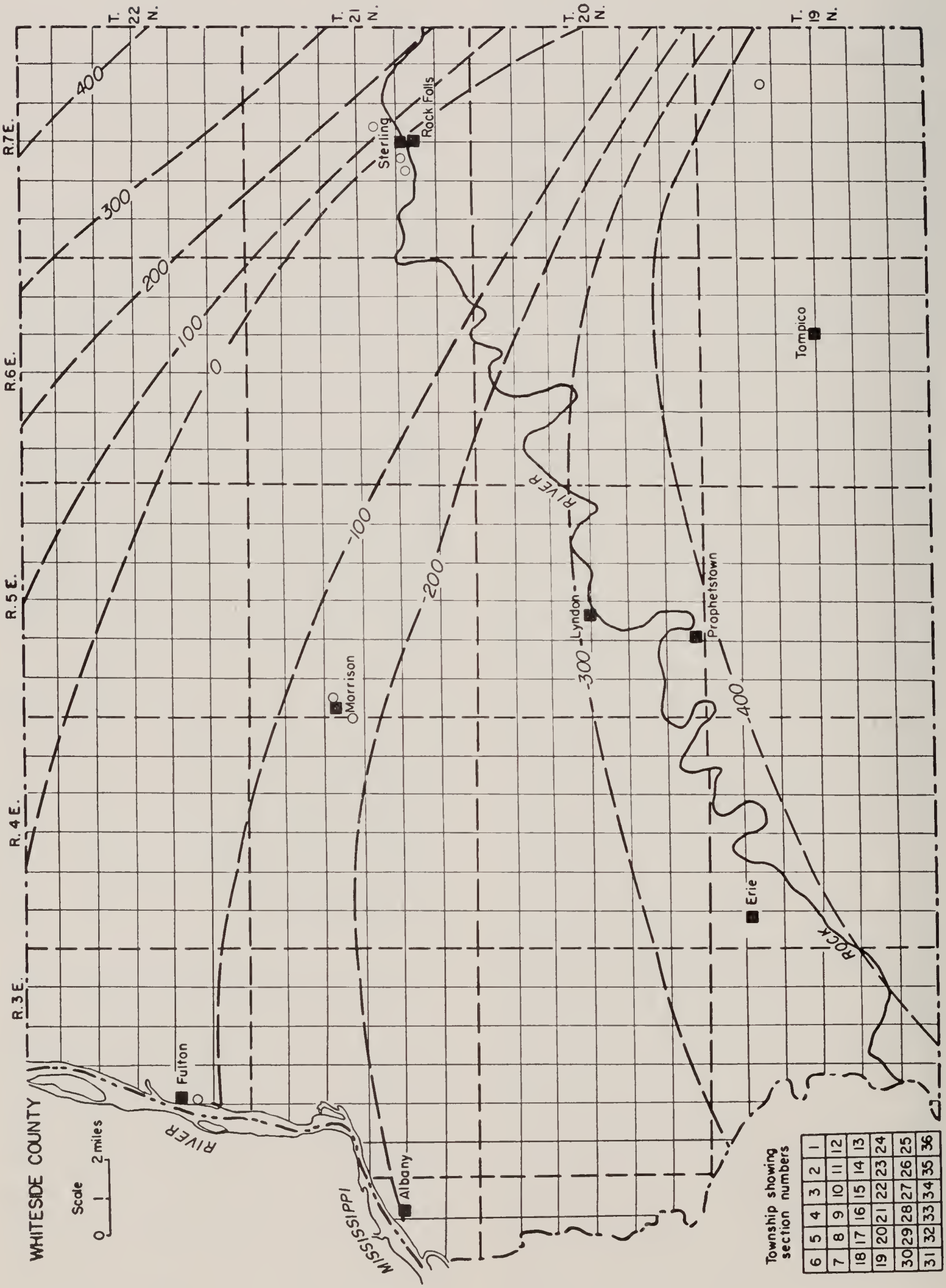
Many water wells drilled to the Galesville formation below the St. Peter are lined in the lower part of the St. Peter or, in some wells, through the entire St. Peter. The casing rests on the dolomite shoulder at the level of hole reduction below the sandstone. In Lee County, where the base of the St. Peter in many places is less than 300 feet deep, some wells are drilled without change in hole size to depths of 400 to 500 feet, to allow ample hole diameter for deep pump installation. However, it is as a rule practical to reduce hole size in the dolomite directly below the St. Peter because deeper casing is generally unnecessary.

An example of a well constructed in St. Peter sandstone is well 3 at the Northwestern Steel and Wire Company, Sterling, near the center of the north line of sec. 28, T. 21 N., R. 7 E., Whiteside Co. Est. elev.: 640 feet. The well was drilled by the Gray Well Company in 1940. Total depth: 760 feet. Well diameter, 12¼ inches to 347 feet, 8 inches to bottom. Eight-inch casing was set and grouted to 347 feet. Part of the log that follows is based on study of drill cuttings on file at the State Geological Survey. Study by R. R. Storm.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift	22	22
Silurian system		
Niagaran-Alexandrian dolomite	103	125
Ordovician system		
Maquoketa shale and dolomite	207	332
Galena–Platteville dolomite	353	685
Glenwood sandstone and shale	10	695
St. Peter sandstone	63	758
St. Peter red shale	2	760

Prairie du Chien Dolomites and Sandstones (Ordovician)

Occurrence.—The Prairie du Chien beds are made up of three formations, the Shakopee dolomite above, the Oneota dolomite below, and the thin intervening New Richmond sandstone. These beds occur throughout Whiteside Co. At least one of the formations occurs throughout Lee County with the exception of a belt largely in T. 38 N., R. 2 E., T. 39 N., Rs. 1 and 2 E., and in T. 22 N., R. 11 E., northeast of Ashton. In this belt the top bedrock is the Trempealeau dolomite (Cambrian) and locally the older Franconia sandstone. The Prairie du


WHITESIDE COUNTY
Scale
0 1 2 miles
T. 22 N.
T. 21 N.
T. 20 N.
T. 19 N.
R. 7 E.
R. 6 E.
R. 5 E.
R. 4 E.
R. 3 E.
400
300
200
100
0
-100
-200
-300
-400
Sterling
Rock Falls
Tampico
Lyndon
Prophetstown
Morrison
Erie
Fulton
Albany
MISSISSIPPI
RIVER
ROCK
RIVER
Township showing section numbers
6 5 4 3 2 1
7 8 9 10 11 12
18 17 16 15 14 13
19 20 21 22 23 24
30 29 28 27 26 25
31 32 33 34 35 36

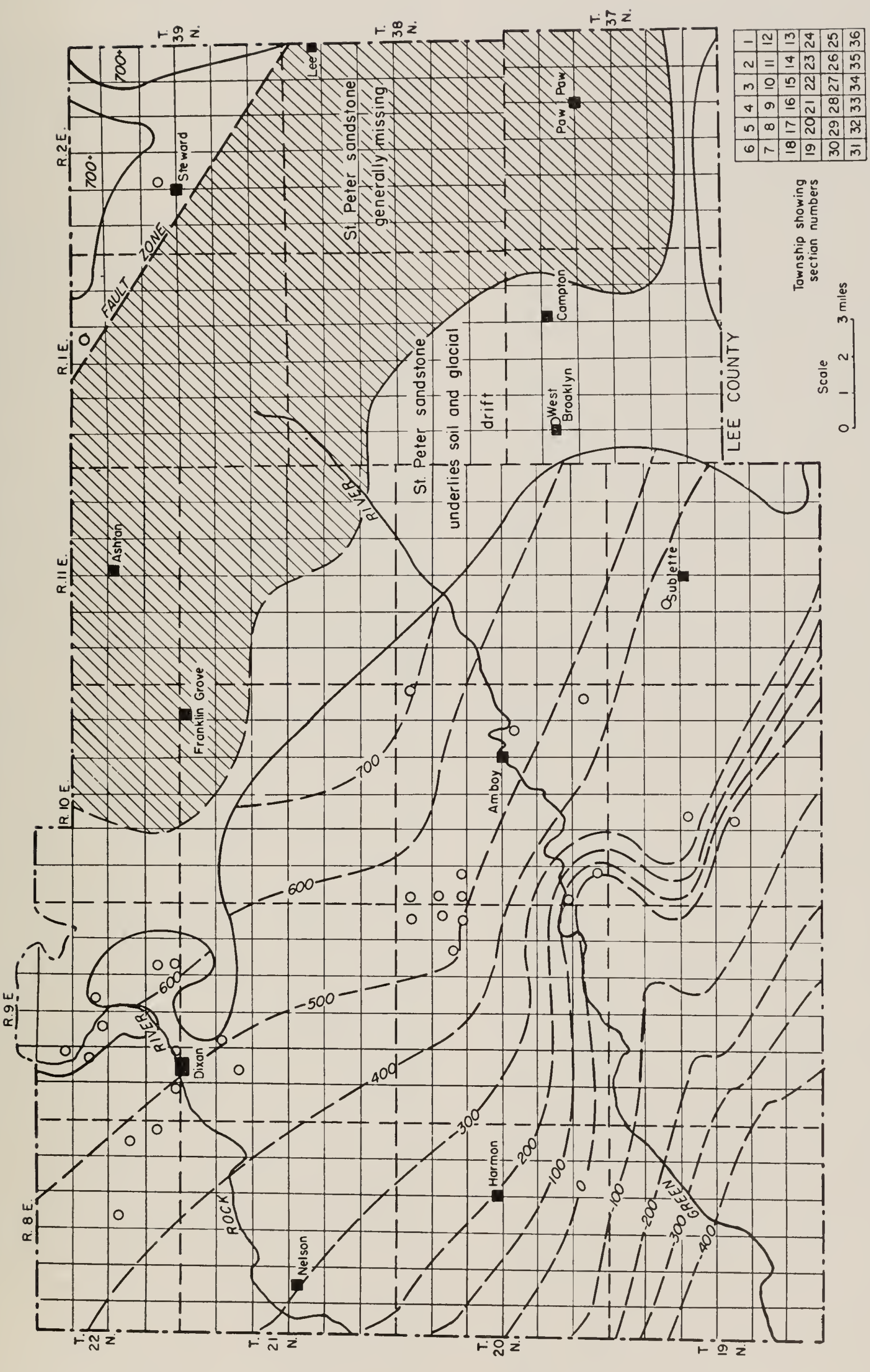


Fig. 8.—Structure contour maps of St. Peter sandstone in Lee and Whiteside counties. Contours show approximate elevation of the top of the water-yielding zones of the St. Peter sandstone in feet above sea level. Circles indicate wells used as control points.

Chien beds lie under the St. Peter sandstone and above the Trempealeau dolomite.

The dolomite beds of the Prairie du Chien series are gray and buff, sandy and cherty in some zones. It is easy to recognize the Shakopee dolomite below the shale zone at the base of the St. Peter, but it is difficult for drillers to distinguish the Shakopee from the Oneota except to note the 10 to 30 feet of New Richmond sandstone that separates them. Near Dixon the New Richmond sandstone contains red and green shale streaks and is normally firm.

The average thickness of Prairie du Chien beds in this area is about 300 feet. At the Northwestern Steel and Wire Company well 1, Sterling (NE¼ NE¼ sec. 29, T. 21 N., R. 7 E., Whiteside Co.), the Prairie du Chien beds are about 375 feet thick, lying at a depth of 765 to 1140 feet. At Dixon Water Company well 5 (SE¼ SE¼ sec. 32, T. 22 N., R. 9 E., Lee Co.), these beds are about 169 feet thick, at depths of 377 to 546 feet. The thickness of the St. Peter sandstone largely controls the thickness of the underlying Prairie du Chien dolomites. Thickening of the St. Peter sandstone is invariably at the expense of the Shakopee dolomite and, in places, the Oneota dolomite.

Between the base of the Prairie du Chien beds and the top of the Trempealeau dolomite, there is in many places a sandstone called the Gunter, which may be as much as 30 feet thick. The break between the dolomites is only a sandy dolomite zone in some places. Except where the sand can be recognized during drilling operations, most holes are continued into the Trempealeau dolomite, without apparent change, because the Oneota and Trempealeau dolomites cannot easily be distinguished in drill holes, except by sample studies.

Water-yielding characteristics.—The dolomite and sandstone beds of the Prairie du Chien are not considered important in the yields of most deep wells in northern Illinois. The dolomites contain some water-bearing cracks, and in places the New Richmond sandstone is permeable enough to yield water. Deep wells, however, are drilled at great expense to tap very favorable beds such as the Galesville sandstone. By comparison, the yields in Prairie du Chien beds are probably not significant.

A marked exception to the general tightness of the Prairie du Chien beds is noted in parts of Lee County where the beds lie directly below glacial drift. At the village of Franklin Grove, Lee Co., a public water well drilled in 1903 to a total depth of 298 feet was reported to yield 100 gallons per minute (Habermeyer, 1925). This well appears to have been drilled no deeper than the Oneota dolomite (lower Prairie du Chien). It indicates that the water-yielding characteristics of the Prairie du Chien dolomites are improved where the beds are not deeply buried, perhaps because there are more crevices in the rock or because otherwise silty crevices have been flushed. These dolomites undoubtedly yield groundwater to many farm wells in Lee County in a broad belt extending southeastward from Franklin Grove and Ashton, particularly where the glacial drift is thin and does not yield water.

Drilling characteristics and well construction.—Prairie du Chien beds normally offer no unusual drilling or construction problems. The dolomites are mostly dense and only rarely contain cavernous openings. Drilling time is similar to that for the Galena-Platteville dolomite except, of course, for differences in depth. The New Richmond sandstone is generally firm enough to maintain open hole, although there may be some enlargement caused by wall weakness where shale streaks are penetrated. Casing these beds is not customary where they are covered by the St. Peter sandstone. But as a precaution against surface pollution, casing and grouting through the New Richmond sandstone are desirable where high-capacity deep wells encounter Shakopee dolomite (upper Prairie du Chien) within 30 feet of the land surface, as in parts of Lee County.

An example of a well apparently completed in Prairie du Chien dolomite is Franklin Grove village well 1, drilled in 1902 to a depth of 298 feet. Location:

NW¼ sec. 1, T. 21 N., R. 10 E., Lee Co. Est. elev.: 810 feet. The well was constructed about 12 inches in diameter to a depth of about 60 feet and fitted with 60 feet of 10-inch casing, with an 8-inch open hole from 60 to 298 feet, the total depth. The geologic record that follows is based on an interpretation of the driller's log.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift . .	30	30
Ordovician system		
Prairie du Chien dolomite . .	268	298

Note: As no samples from this well are available for study, it is not certain that this well taps water exclusively from the Prairie du Chien dolomites and sandstones. The upper part of the Trempealeau formation may have been penetrated.

Trempealeau Dolomite (Cambrian)

Occurrence.—The Trempealeau dolomite is generally a light-gray somewhat sandy formation with an average thickness of about 150 to 170 feet in Lee and Whiteside counties. It lies beneath the Oneota dolomite (lower Prairie du Chien), in places separated from it by the thin Gunter sandstone. Where the Gunter cannot be recognized, the driller finds it difficult to distinguish Oneota from Trempealeau, although the Trempealeau is generally more sandy. Below the Trempealeau lie the sandstone, shale, and dolomite beds of the Franconia formation.

The Trempealeau dolomite occurs throughout Whiteside County and throughout Lee County except in part of northwestern T. 39 N., R. 1 E., where the Franconia formation lies directly beneath glacial drift. In T. 22 N., R. 11 E. (northeast of Ashton), northern T. 39 N., R. 1 E., southwestern T. 39 N., R. 2 E., and eastern T. 38 N., R. 2 E., Lee Co., Trempealeau dolomite lies directly beneath glacial drift. In the lowlands of southwestern Whiteside County the Trempealeau dolomite is about 1325 feet deep.

Water-yielding characteristics. — The Trempealeau formation yields some water to most wells in northern Illinois. Groundwater from the Trempealeau dolomite is obtained from open fractures and solution channels. At many sites in northeastern Illinois the Trempealeau dolomite is highly water-yielding, particularly where cavernous openings have been discovered. Some wells there, designed to tap water from the deeper Galesville sandstone, are believed to obtain most of their water from the Trempealeau formation. In Lee and Whiteside counties, the Trempealeau dolomite does not appear to have openings as abundant as in northeastern Illinois, but its yield is probably significant in many deep wells.

In parts of northeastern Lee County, where Trempealeau dolomite is shallow, a number of farm wells tap groundwater from it or from both the Oneota and Trempealeau dolomites. The Trempealeau probably can yield at least domestic supplies of water at practically all locations. It is attractive for drilled wells in parts of northeastern Lee County where it is shallow and where the glacial drift contains no water-bearing sands.

Drilling characteristics and well construction.—The Trempealeau dolomite is readily penetrated by cable tools except in those places where cavernous openings and inclined walls are discovered. In Lee and Whiteside counties these troublesome openings are believed to be rare, although fissures and cracks are not. Most Trempealeau openings probably contain sand but they do not normally contain silt or clay in troublesome quantity. Wells penetrating Trempealeau cracks pump little or no sand. Casing or lining is not needed to maintain open hole or to prevent contamination by silt and clay.

An example of a well completed in Trempealeau dolomite is one located on the Atwood farm in the NE¼ sec. 23, T. 39 N., R. 1 E., Lee Co., west of Steward. The well is 167 feet deep, with 114 feet of 6-inch casing and a 6-inch open hole from 114 to 167 feet. The geologic record that follows is based on interpretation of the driller's log.

	Thickness feet	*Depth feet*
Pleistocene series		
Till, clayey and pebbly, tight .	110	110
Cambrian system		
Trempealeau dolomite . . .	57+	167

Franconia Sandstone, Shale, and Dolomite (Cambrian)

Occurrence.—Franconia beds lie below the Trempealeau dolomite. They occur generally throughout Lee and Whiteside counties and are 80 to 110 feet thick. They are exposed in a small area in T. 39 N., R. 1 E., Lee Co., and are the oldest exposed beds known in Illinois. Although the Franconia formation is sandy, sandstone actually composes less than half the formation at most places; at least half the beds are gray-green shale or sandy dolomite. The sandstone beds commonly contain more dolomite and glauconite (a greenish mineral) and are finer grained than the underlying Ironton and Galesville sandstones. Where the top few feet of the Franconia is dolomite, this dolomite cannot be easily distinguished from the Trempealeau dolomite above, which also tends to be sandy in its lower part. But the streaks of slightly greenish sandstone which invariably show in the upper Franconia allow easy identification of that formation as drilling progresses.

Water - yielding characteristics. — The Franconia is not a significant groundwater source in deep, high-capacity wells in most of northern Illinois, except near the Wisconsin line, where its sandstone beds are apparently thicker, cleaner, and more permeable than in areas to the south. In T. 39 N., R. 1 E., Lee Co., a few farm wells penetrate 50 to 80 feet into the Franconia and apparently obtain satisfactory supplies from permeable sandstone beds or from open cracks in the harder, tighter beds. The limited permeability of the Franconia sandstone probably is due largely to its dolomite content and firmness. A few zones are weak and soft, but they are apparently not as common in Lee and Whiteside counties as in northeastern Illinois.

Drilling characteristics and well construction.—No special drilling problems are normally associated with the Franconia formation in the Lee-Whiteside region. Drilling time is reported to be slow in sandstone beds tightly cemented with dolomite. The shale beds are more firm than, for example, the Maquoketa shale, and lining a well to maintain open hole is not usually necessary.

Because the Franconia formation is normally overlain and underlain by favorable water-bearing beds—the Trempeleau dolomite above and the Galesville sandstone below—the only wells designed to tap Franconia beds are located in T. 39 N., R. 1 E., northeastern Lee Co., where the formation lies directly below tight glacial drift.

One of the wells tapping water exclusively from the Franconia is that on the Vogeler farm, sec. 20, T. 39 N., R 1 E., Lee Co., southeast of Ashton. The well has a total depth of 141 feet, with 6-inch casing from the surface to a depth of 90 feet. Diameter of the open hole below 90 feet is unknown. The geologic record that follows is based on interpretation of the driller's log.

	Thickness feet	*Depth feet*
Pleistocene series		
Humus over yellow-to-blue clay till	75	75
Sand and gravel (apparently non-permeable)	5	80
Cambrian system		
Franconia formation		
Sandstone, white	10	90
Sandstone, gray	25	115
Sandstone, yellow	26	141

Ironton-Galesville Sandstone (Cambrian)

For many years the sandstone and dolomite streaks between the Franconia and Eau Claire formations in northern Illinois were grouped into one formation, known as the Dresbach sandstone (Thwaites, 1927, p. 28). Later this formation became known as the Galesville sandstone; most drillers working in the deep sandstones in northern Illinois use the term Galesville. Even before 1940, however, the Illinois State Geological Survey recognized that the Galesville sandstone in most wells was readily divisible into two distinct beds. The upper bed was called the Ironton formation and the lower bed the Galesville. The Ironton-Galesville break is based largely on differences in texture and in the minerals composing the rocks. As each formation contains one or more water-yielding zones, the formation is called Ironton-Galesville in this report.

Occurrence. — The Ironton-Galesville sandstone has been found in almost all borings in northern Illinois that have penetrated below the Franconia formation. It is about 130 to 160 feet thick. In this area it is underlain by the Eau Claire shales and sandstones. At the Northwestern Steel and Wire Company well 1, Sterling, the formation is about 157 feet thick; at the Dixon State Hospital well 2, it is about 133 feet thick.

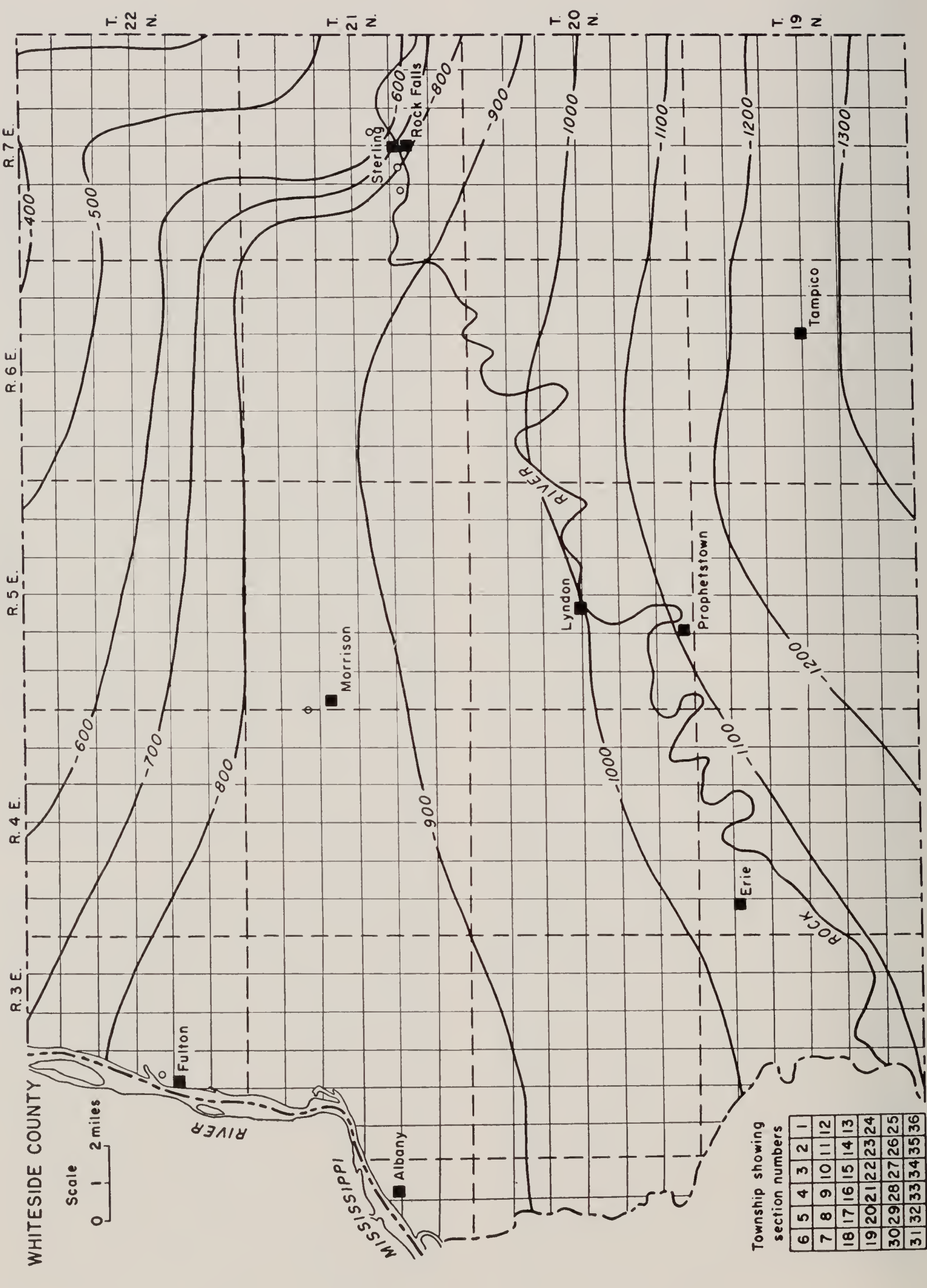
Figure 9 shows the approximate elevation of the top water-yielding zone of the Ironton-Galesville formation. Like most bedrock formations in this region, this sandstone dips gently southwestward from northeastern Lee County to southern Whiteside County. The top of the Ironton-Galesville is about 455 feet deep at Ashton, Lee Co., and about 1600 feet deep at Erie, Whiteside Co. The top can be recognized by a change from thin hard dolomitic greenish-gray sandstone (Franconia) to lighter gray softer locally reddish sandstone (Ironton). The base of the Galesville is recognized by a change to a dark hard shale 10 to 25 feet thick (upper Eau Claire).

Water-yielding characteristics. — The Ironton-Galesville beds have long been considered the most favorable deep rock aquifer in Illinois. The generally good water-yielding characteristics of this sandstone result from a number of geologic conditions. (1) The sandstone has several zones with good-to-excellent permeability, at some locations comprising up to half the thickness of the formation. (2) The zones of good permeability appear to have wide lateral extent; the same zone can be traced from well to well in some areas. (3) The sandstone has more-or-less uniform thickness over thousands of square miles. (4) Recharging can take place in some areas in step-like fashion through overlying formations, particularly in that portion of northern Illinois where the Maquoketa shale is not present to bar surface infiltration (fig. 3). (5) The southerly dip of the formation, together with hydrologic interconnection with overlying water-bearing beds, has created naturally high water-pressure potential.

The Ironton-Galesville sandstone is popular in northern Illinois as a source of municipal and industrial groundwater, not only because of its favorable water-yielding characteristics but also because of its widespread occurrence. This enables well sites to be selected largely on the basis of convenience. Furthermore, the Ironton-Galesville formation is sufficiently consistent to enable well specifications to be drawn in advance of drilling. Regardless of the shortcomings of rigid well specifications, they are apparently desirable from an economic standpoint and are an attractive feature of the development of the Ironton-Galesville sandstone as opposed to surficial sand and gravel or to the shallower dolomites.

Shooting the Ironton-Galesville sandstone with explosives to increase yield is common practice in northeastern Illinois. If shooting zones are carefully selected on the basis of sample studies and/or electric logs, the bore hole can be enlarged to several times the diameter of the bit, and marked increase in yield will be noted. This method requires extensive well cleaning after shooting to open the well to its original depth. Shooting is probably best adapted to rehabilitating old wells or to improving new wells that show a disappointing specific capacity. The State Geological Survey has no record of shooting operations in the Ironton-Galesville sandstone in Lee and Whiteside counties.

Drilling characteristics and well construction.—Drillers report that the Ironton-Galesville sandstone presents no serious problems in drilling. Because there is much caving, the formation is treated like the St. Peter sandstone—short drilling intervals and frequent and thorough bailing. This hazard is not so great as in the St. Peter, possibly because there is less contrast between weak and firm beds. Caliper logs of deep wells in many parts of northern Illinois show that, even without shooting, a bore hole in the Ironton-Galesville sandstone is often enlarged to 2 to 4 times bit diameter by spontaneous caving. This characteristic is probably very significant in the yield of deep sandstone wells. These zones of caved sandstone may also be important in trap-


WHITESIDE COUNTY
Scale
0 1 2 miles
Township showing section numbers
6 5 4 3 2 1
7 8 9 10 11 12
18 17 16 15 14 13
19 20 21 22 23 24
30 29 28 27 26 25
31 32 33 34 35 36
T. 22 N.
T. 21 N.
T. 20 N.
T. 19 N.
R. 7 E.
R. 6 E.
R. 5 E.
R. 4 E.
R. 3 E.
Sterling
Rock Falls
Morrison
Tampico
Lyndon
Prophetstown
Erie
Fulton
Albany
MISSISSIPPI
RIVER
ROCK
RIVER
400
500
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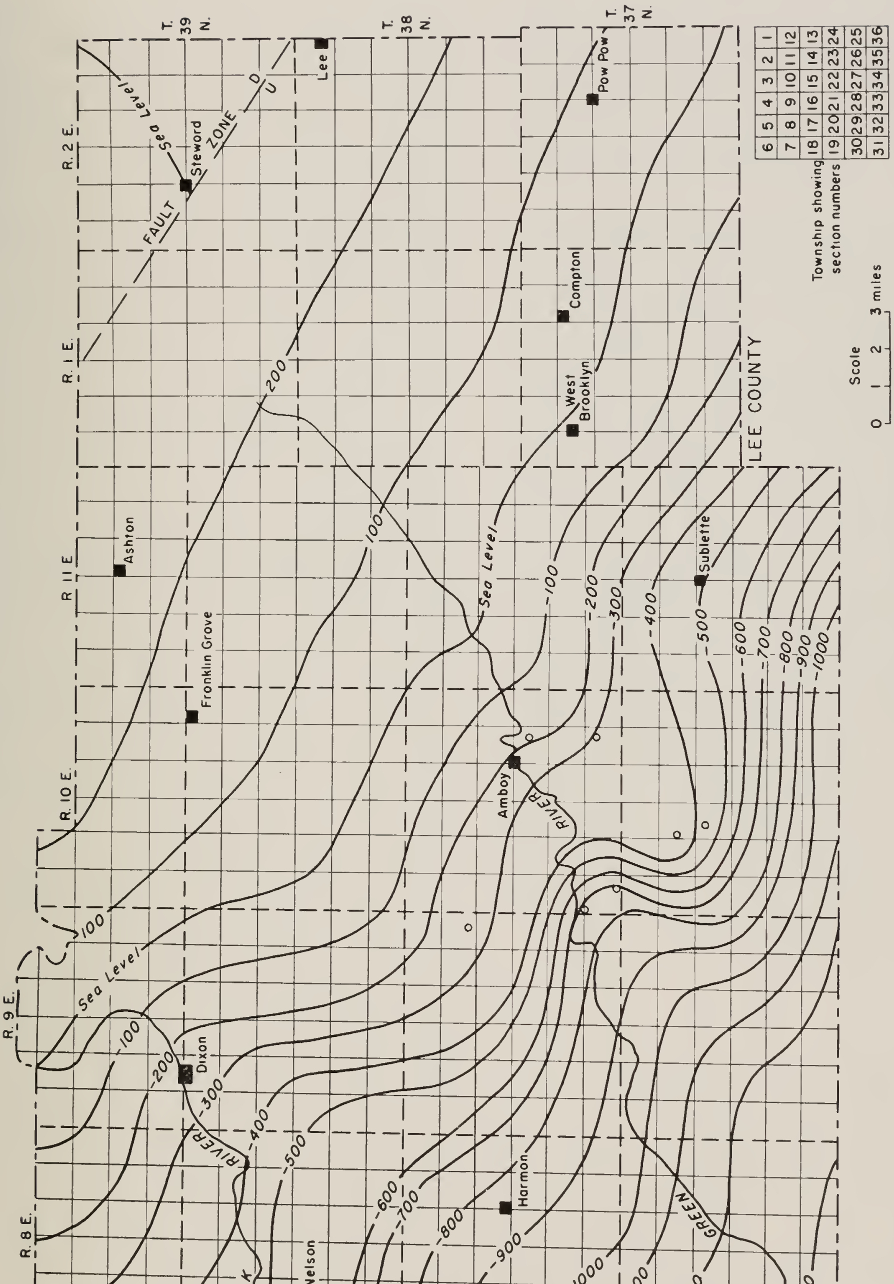
900
1000
1100
1200
1300



6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

FIG. 9.—Structure contour maps of Ironton-Galesville sandstone in Lee and Whiteside counties. Contours show approximate elevation of the top of the water-yielding zones of the Ironton-Galesville sandstone in feet above sea level. Circles indicate wells used as control points.

ping fine-grained sand and silt during pumping because the enlarged hole causes loss of water velocity at that zone.

Lining is not used in the Ironton-Galesville sandstone even when wells penetrate to the deeper Mt. Simon sandstone. Care should be taken to construct at least 20 to 50 feet of "rat hole" below the sandstone to collect caving sand during the life of the well.

No wells in Lee and Whiteside counties are known to tap water exclusively from the Ironton-Galesville sandstone. Most deep water wells in the region are open to the water-yielding St. Peter sandstone and Trempealeau dolomite, the two shallower formations probably most significant in supplementing the yield of wells in the Ironton-Galesville sandstone. Northern Illinois Water Corporation well 1 at Sterling (NE¼ NW¼ sec. 28, T. 21 N., R. 7 E., Whiteside Co.) is considered a typical deep well designed to tap the Galesville sandstone. This well was drilled in 1939 by the Gray Well Company. Elev.: 630 feet. Casing and hole schedule: 10-inch hole reduced at 780 feet, and 20 feet of 8-inch liner installed to 780 feet (liner cases off the caving shale and sandstone in the lower part of the St. Peter formation); 8-inch hole without lining from 780 to total depth of 1580 feet. The geologic record that follows is based on study of drill cuttings (sample set 3798). Study by Elwood Atherton.

	Thickness feet	*Depth feet*
Recent cinder fill	12	12
Silurian system		
Niagaran–Alexandrian dolomite	131	143
Ordovician system		
Maquoketa shale and dolomite	202	345
Galena–Platteville dolomite	345	690
Glenwood dolomite and sandstone	35	725
St. Peter sandstone	50	775
Shakopee dolomite	135	910
New Richmond sandstone	25	935
Oneota dolomite	185	1120
Gunter sandstone and dolomite	30	1150
Cambrian system		
Trempealeau dolomite	180	1330
Franconia dolomite and sandstone	100	1430
Galesville sandstone	145	1575
Eau Claire shale	5+	1580

Eau Claire Sandstone and Shale (Cambrian)

Occurrence.—The Eau Claire formation lies directly beneath the Galesville sandstone and above the Mt. Simon sandstone. Eau Claire beds are mostly sandstone, particularly in the lower half of the formation, but shale is abundant in the upper portion; a few thin dolomite beds also occur. The shales and dolomites of the Eau Claire formation represent essentially the only breaks in an otherwise continuous sequence of sandstone from the top of the crystalline basement rock to the Franconia. Eau Claire beds are believed to occur throughout Lee and Whiteside counties. They are about 400 to 420 feet thick where penetrated to date, except at Dixon Water Company well 5 (SE¼ sec. 32, T. 22 N., R. 9 E., Lee Co.), where the Eau Claire is 450 feet thick, according to studies of drill cuttings.

At Dixon, and apparently at Sterling, the upper 35 to 100 feet of Eau Claire is mostly greenish shale. But at the Green River Ordnance Plant (sec. 12, T. 20 N., R. 9 E.) and at Amboy (sec. 22, T. 20 N., R. 10 E.) in Lee County the upper Eau Claire beds are sandstone. The top of the Eau Claire can be recognized either by the greenish shale or by hard, dolomitic sandstone below soft Galesville sandstone.

Water-yielding characteristics.—The Eau Claire beds are not as a rule considered an important water-yielding zone in most of northern Illinois, but where the lower half of the formation is soft white sandstone, as at Dixon well 5, they are probably important aquifers. The sandstones of the lower Eau Claire are 150 to 250 feet thick over hundreds of square miles in northwestern Illinois and contain enormous quantities of fresh water in storage. Their permeabilities probably are less than those of the Ironton-Galesville, but at some places in Lee and Whiteside counties they appear to have good permeability. No electric logs or flow-meter surveys have been run in the Eau Claire in this region, so precise data are lacking.

Drilling characteristics and well construction.—No serious drilling problems are as-

sociated with the Eau Claire formation in northwestern Illinois. There may be occasional caving, but both the shales and sandstones are normally firm enough to maintain open hole in unlined wells drilled through to the Mt. Simon sandstone. Material that caves during drilling in the Eau Claire is probably mostly Ironton-Galesville that spalls from the agitation of the drill. Some of the dolomite-cemented sandstones of the Eau Claire drill hard and slowly, but in the lower half, the formation is softer. Wells drilled into the Eau Claire formation in this area have been for the purpose of tapping the deeper Mt. Simon sandstone.

Mt. Simon Sandstone (Cambrian and Pre-Cambrian?)

Occurrence.—The deepest sedimentary rock known to occur in northwestern Illinois is the Mt. Simon sandstone. It lies directly on crystalline basement rock—granite and felsite. The Mt. Simon thickens and thins with the undulation of the surface of the crystalline basement. As crystalline basement has been touched by the drill only at scattered locations in northern Illinois (Grogan, 1949, p. 97-102), its topography is not well known. Two oil test borings in Lee County (secs. 35 and 30, T. 20 N., R. 10 E.) went through the Mt. Simon sandstone and struck the granite at depths of 3465 and 3760 feet. In Vedovell 1, sec. 35, the Mt. Simon sandstone extended from 1700 to 3465 feet, a thickness of 1765 feet. In McElroy 1, sec. 30, the Mt. Simon extended from 1795 to 3760 feet, a thickness of 1965 feet. The thickness of the Mt. Simon sandstone in Whiteside County is not known, because there have been no borings to the crystalline basement. In southwestern Whiteside County the thickness of the Mt. Simon may be less than 1000 feet. The top of the formation there is probably 500 to 700 feet lower than in parts of Lee County, and the surface of the granite may rise to levels higher than those encountered in T. 20 N., R. 10 E., Lee Co.

The top of the Mt. Simon sandstone can as a rule be distinguished from the Eau Claire beds above by an increase in coarseness and a decrease in hardness. Mt. Simon beds are not commonly cemented with dolomite, but many of them contain reddish zones caused by an iron-oxide film on the quartz grains (Templeton, 1950, p. 153). The top of the Mt. Simon probably ranges from about 1250 feet deep in the Ashton area, Lee Co., to about 2150 to 2300 feet deep near Erie, Whiteside Co.

Water-yielding characteristics. — Many wells in northern Illinois and a few in Lee County have been drilled into the Mt. Simon sandstone. No wells penetrate the entire thickness of the formation because depths are economically prohibitive and water quality apparently diminishes with depth. Drill cuttings from the Dixon area and from oil tests in T. 20 N., R. 10 E., Lee Co., indicate that the grains of Mt. Simon sandstone are generally poorly sorted and range from fine sand or even silt size to coarse sand. The presence of abundant "fines" more than offsets the advantage of coarseness. Most of the water from the Mt. Simon seems to come from zones of well-sorted medium sand which make up about 10 percent of the formation.

The following are geologic records of water wells drilled into the Mt. Simon sandstone in Lee County.*

Well	Location	Total depth (feet)	Elev. of well bottom (feet below sea level)	Penetration in Mt. Simon sandstone (feet)
Dixon well 5	sec. 32, T. 22 N., R. 9 E.	1700	1040	275
Dixon State Hosp. well 1	sec. 21, T. 22 N., R. 9 E.	1922	1232	652
Dixon State Hosp. well 2	sec. 21, T. 22 N., R. 9 E.	1780	1100	501
Green River Ordnance Plant 1	sec. 12, T. 20 N , R. 9 E	1735	970	180

* The Geological Survey has no accurate record of Mt. Simon wells in Whiteside County although one of the early Sterling Water Works wells is reported to have been drilled to a total depth of 1829 feet, possibly to the top of the Mt. Simon.

T. E. Larson, Chemist, State Water Survey, has found that as the Mt. Simon sandstone increases in depth below about 1000 feet below sea level, the mineral content of the water increases toward the limit of tolerance. As the top of the sandstone is well below minus 1000 feet in a large part of southern Whiteside County, the quality of Mt. Simon water there is questionable.

Drilling characteristics and well construction.—The Mt. Simon is well suited to cable-tool drilling because it is generally soft to the bit but firm in the open hole. There is some caving where the beds are uncommonly weak. Cutting should not advance too far beyond the sand pump, particularly in the weak zones. Diameters in wells in the Mt. Simon formation in Lee County range from 8 to 15 inches. No lining has been used in the Mt. Simon in this region, according to available records.

There are no wells in Lee and Whiteside counties that tap water exclusively from the Mt. Simon sandstone. However, a number of wells in Lee County penetrate the Mt. Simon and obtain water from it as well as the Eau Claire, Galesville, and St. Peter sandstones, Trempealeau dolomite, and possibly other formations. One such well is Dixon city well 5 (SE¼ SE¼ sec. 32, T. 22 N., R. 9 E.), drilled in 1945 by the Varner Well Company to a depth of 1700 feet; 23 inches, 26 to 160 feet; 19 inches, 160 to 547 feet; 15 inches to 1700 feet. Casing schedule: 26 feet of surface casing; 18-inch O. D. casing to 183 feet, grouted; 16-inch O. D. casing 314 feet to 547 feet (lines the lower St. Peter to the top of the Trempealeau). Est. elev.: 660 feet. The geologic record that follows is based on a study of drill cuttings on file in the State Geological Survey. Study by M. P. Meyer.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift	8	8
Ordovician system		
Galena–Platteville dolomite	112	120
Glenwood sandstone and shale	45	165
St. Peter sandstone (22 feet of shale at base)	212	377
Shakopee dolomite	38	415
Oneota dolomite	131	546
Cambrian system		
Trempealeau dolomite	184	730
Franconia dolomite and sandstone	100	830
Ironton–Galesville sandstone	145	975
Eau Claire shale, dolomite, and sandstone	450	1425
Mt. Simon sandstone	275+	1700

PUBLIC WATER SUPPLIES IN WHITESIDE COUNTY

Erie

Until 1952 the public water supply at Erie was obtained from a drilled well constructed in 1920 to a reported total depth of 567 feet. This well apparently extended 400 feet into solid rock and probably tapped water principally from the Niagaran dolomite. In 1952 a test well was drilled to the top of the bedrock at a depth of 173 feet to test water-bearing sand and gravel deposits; they were found to extend continuously from the surface to bedrock. In 1953 a permanent gravel-pack well was installed with a 25-foot screen at the bottom of the sand and gravel.

The 1952 test hole and 1953 gravel-pack well at Erie showed the unconsolidated sand and gravel to have great promise for municipal and industrial water supplies. These water-bearing deposits are believed to thicken northward from Erie for a mile or more. It is not likely that deep drilling into bedrock will be necessary in the future.

Fulton

The public water supply at Fulton is obtained from two drilled wells, No. 2 constructed in 1908 and No. 3 constructed in 1931. Well 2 was 1260 feet deep at the time of construction and apparently designed to tap water principally from Trempealeau dolomite and St. Peter sandstone. Well 3 was drilled to a depth of 1943 feet, penetrating about 133 feet into the Mt. Simon sandstone. This well probably taps water from the Mt. Simon and Galesville sandstones and the Trempealeau dolomite in unknown proportions. The St. Peter sandstone is lined but not grouted.

Possibilities are excellent that deposits of water-bearing sand and gravel at depths as great as 250 feet, suitable for a municipal

water supply, occur in the immediate vicinity of Fulton. The best locations to test for permeable sand and gravel appear to be in the extreme southeastern corner of the village and possibly near the river in the southwestern part. There seems to be little need for deep drilling into bedrock.

The geologic record that follows is based on a study of drill cuttings from Fulton city well 3. Location: 2280 feet north and 3980 feet west of SE corner sec. 28, T. 22 N., R. 3 E. Est. elev.: 600 feet. Study in part by F. T. Thwaites.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift and alluvium (no record and no samples)	100	100
Clay, blue	10	110
Gravel grading to sand	50	160
Clay, brown	10	170
Ordovician system		
Maquoketa shale, some dolomite	172	342
Galena–Platteville dolomite	330	672
Glenwood shale and sandstone	18	690
St. Peter sandstone (15 ft. of shale at base)	65	755
Prairie du Chien dolomites and thin sandstones	415	1170
Cambrian system		
Trempealeau dolomite	160	1330
Franconia shaly sandstone	100	1430
Galesville sandstone		
dolomitic	50	1480
loose and permeable	50	1530
dolomitic	20	1550
Eau Claire sandstone and shale	260	1810
Mt. Simon sandstone	133+	1943

Morrison

The public water supply at Morrison is obtained from three drilled wells, the east well drilled in 1897 to a depth of 1643 feet, the west well drilled in 1912 to 2048 feet, and well 3 drilled in 1950 to 1625 feet. Water probably enters the east and No. 3 wells principally from Galesville and St. Peter sandstones and Trempealeau dolomite. It probably enters the deeper west well principally from Mt. Simon and Galesville sandstones and Trempealeau dolomite; the St. Peter in this well is reported to be cased off.

Shallow water-bearing sand and gravel deposits may be available for municipal water supply development at Morrison. In July 1953 the State Geological Survey conducted an electrical earth resistivity study of the Morrison area to explore for water-bearing deposits above bedrock, generally shallower than 100 feet. Promising areas appear to lie west and southeast of Morrison. Suggested sites for testing have been described in an unpublished geologic report made for the city of Morrison. Whether Morrison can eventually develop a municipal water supply exclusively from glacial sand and gravel beds is unknown.

The geologic record that follows is based on study of drill cuttings from well 3. Location: NW¼ SW¼ sec. 18, T. 21 N., R. 5 E. Est. elev.: 670 feet. Study by P. M. Busch.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift (no samples)	90?	90?
Silurian system		
Niagaran–Alexandrian dolomite	168	258
Ordovician system		
Maquoketa shale and dolomite	182	440
Galena–Platteville dolomite	345	785
Glenwood shale and sandstone	15	800
St. Peter sandstone (10 ft. of shale at base)	135	935
Prairie du Chien dolomites	155	1090
Cambrian system		
Trempealeau dolomite	335	1425
Franconia sandstone and dolomite	70	1495
Galesville sandstone	125	1620
Eau Claire sandstone and dolomite	5+	1625

Prophetstown

The public water supply at Prophetstown is obtained principally from a well drilled in 1944 to a depth of 235 feet. It penetrates 42 feet into Niagaran dolomite and apparently taps open cracks. About 180 feet of sandstone is cased off. The public water system is reported to be interconnected with wells of the Eclipse Lawn Mower Company. One Eclipse test well was drilled 1052 feet deep, 86 feet below the base of the St. Peter sandstone.

Geologic conditions at Prophetstown appear suitable for municipal and industrial supplies of groundwater from unconsolidated sand beds above bedrock. These deposits extend to a depth of about 190 feet. Fine sand in the water-bearing deposits sug-

gests the need for gravel-pack well construction at some locations. In some cases it may be economical to tap water-bearing cracks in the Niagaran dolomite at a depth of 230 to 275 feet, but deep drilling in solid rock appears unnecessary.

Sterling–Rock Falls

Until 1953 the public water supply at Sterling–Rock Falls was obtained from drilled wells 1600 to 1800 feet deep, penetrating Mt. Simon sandstone. The principal sources of water for these wells are the Mt. Simon and Galesville sandstones and, to a lesser extent, the St. Peter sandstone and the Trempealeau and Galena-Platteville dolomites. Most deep wells at Sterling and Rock Falls are cased and grouted to a depth of at least 100 feet, shutting off Niagaran dolomite crevices, which are potentially polluted because of their exposure along the Rock River. Wells generally have 70 to 100 feet of liner through the lower part of the St. Peter sandstone, seated on the underlying Shakokee dolomite, to prevent caving and bridging in the weak sandstones and red shale zones.

Thick beds of sand and gravel have long been known from southern Rock Falls southward for many miles. Most private water supplies in that area are obtained from sand points driven 20 to 45 feet deep. The practicability of constructing high-capacity water wells in these surficial deposits was not realized until 1952, when 50 drive points were heavily pumped by common suction to lower the water table temporarily below the level of sewer construction. These drive points yielded more than 2000 gallons per minute for several weeks. When pumping stopped the water table promptly resumed near-normal level. At the request of the Northern Illinois Water Corporation, the Illinois State Geological Survey conducted a microseismograph survey northwest of Sterling and south of Rock Falls in the spring of 1953 to locate areas of lowest bedrock surface or maximum thickness of surficial deposits over dolomite. Reports were prepared, and in July 1953 four locations were tested by the Layne–Western Company with a 4-inch rotary rig, two in sec. 19, T. 21 N., R. 7 E., and two in sec. 33, T. 21 N., R. 7 E.; results at three locations were favorable. Gravel-pack well construction was begun September 1953 at the site of test hole 1, approximately 500 feet west and 500 feet south of the center of sec. 33, T. 21 N., R. 7 E.

Because of the extensive occurrence of highly permeable surficial sands and gravels south of Rock Falls, this area appears to have considerable industrial and public water potential. Groundwater development in the area should be made with full recognition of some pollution hazard caused by lack of an impervious cover of tight clay.

The geologic record of test hole 1 that follows is based on a study of drill cuttings. Est. elev.: 640 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Sand, yellow, medium, oxidized, clean, noncalcareous . . .	5	5
Gravel and sand, yellow, slightly silty, calcareous	5	10
Gravel and sand, cleaner, scattered clay balls	5	15
Sand, yellow, coarse, sorted, clean, calcareous	5	20
Gravel and sand, yellow, clean, poor sorting, calcareous . .	10	30
Sand and fine gravel, with noncalcareous brown silt streaks .	10	40
Sand, medium clean, with gravel streaks	15	55
Clay, buff, slightly pink, calcareous, with gravel below . . .	5	60
Gravel, coarse, clean, with clayey streaks	12	72
Silurian system		
Niagaran dolomite	4+	76

The geologic record that follows is based on interpretation of the driller's log of well 3, Northern Illinois Water Corporation. Location: approx. center S½ sec. 22, T. 21 N., R 7 E. Est. elev.: 660 feet.

	Thickness feet	*Depth feet*
Silurian system		
Niagaran–Alexandrian dolomite .	10–40	(25)
Ordovician system		
Maquoketa shale and dolomite .	160	185
Galena–Platteville dolomite . .	320	505
Glenwood–St. Peter sandstone, red shale at base	188	693
Prairie du Chien dolomite and sandstone	157	850

Cambrian system		
Trempealeau dolomite . . .	125	975
Franconia sandstone and shale .	200	1175
Galesville sandstone	145	1320
Eau Claire shale and sandstone .	240	1560
Mt. Simon sandstone and dolomitic sandstone	269	1829

Tampico

The public water supply at Tampico is obtained from a series of sand points driven to a depth of about 30 feet. At most locations the shallow water-bearing beds probably extend from just below the surface to the top of the bedrock. These beds make up the broad expanse of the sand plain throughout most of southern Whiteside County. Very little drilling information is available because wells are predominantly sand points from which little geologic data can be obtained. The sand and gravel bed at Tampico is about 35 to 75 feet thick; it is believed to thicken to the south. Permeability probably is good in one or more zones at most locations. The formation appears to have considerable promise for low-cost development of industrial groundwater. It is important that wells be adequately spaced to accord with good engineering practice. Because there is no continuous tight clay cover over the formation in this area, some hazard of pollution appears to exist where wells are improperly located with respect to waste-disposal units.

PUBLIC WATER SUPPLIES IN LEE COUNTY

Amboy

The public water supply at Amboy is obtained chiefly from well 2, drilled in 1924 to a depth of 1100 feet and designed to tap the Galesville sandstone at 950 feet. The casing record is unknown, but the well is reported at least partially bridged at a depth of 162 feet. Assuming the well is still open to its original depth, groundwater is probably obtained from the Galesville, Trempealeau, St. Peter, and Galena-Platteville formations in unknown proportions. Well 1 was drilled in 1891 to a depth of 2012 feet and probably penetrated at least 650 feet into the Mt. Simon sandstone.

The best possibilities for future drilling appear to be the Galesville sandstone or, possibly, shallower dolomite formations, should any sufficiently fractured be found. Shallow sand and gravel deposits in the Green River lowland occur in sec. 24, two miles east of Amboy, but no large water-bearing sand and gravel beds are known close to the community. Prospecting for shallow sand and gravel would be justified in secs. 22 and 23, south of Amboy, if shallow-well construction is desired.

The geologic record that follows is based on study of samples from Amboy well 2. Location: NW¼ NE¼ sec. 22, T. 20 N., R. 10 E. Est. elev.: 740 feet. Study by Elwood Atherton.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift . .	21	21
Ordovician system		
Galena–Platteville dolomite . .	159	180
Glenwood–St. Peter sandstone .	175	355
Shakopee dolomite	40	395
New Richmond sandstone . .	40	435
Oneota dolomite	185	620
Cambrian system		
Jordan dolomite and thin sandstone	60	680
Trempealeau dolomite . . .	165	845
Franconia dolomite and sandstone	105	950
Galesville sandstone	150+	1100

Ashton

The public water supply at Ashton is obtained from a well drilled in 1915 to a depth of 544 feet, probably to the top of the Galesville sandstone. The well is reported to be cased to a depth of 180 feet. Yield is probably partly from the Galesville sandstone and partly from the Trempealeau dolomite. This is supplemented by a drilled well owned by the Chicago and Northwestern Railroad, drilled in 1904 to a depth of 249 feet—about 75 feet into the Trempealeau dolomite.

The best future possibilities for groundwater appear to be the Galesville sandstone, 455 to 600 feet deep, and the shallower Trempealeau dolomite, which appears to be fractured and water-yielding at many locations in the area. Ashton is poorly situ-

ated for shallow wells in sand and gravel, as no suitable deposits are believed to occur close enough to be economically developed.

The geologic record that follows is based on a study of samples from the Chicago and Northwestern Railroad well. Location: near center sec. 27, T. 22 N., R. 11 E. Est. elev.: 835 feet. Study by M. P. Meyer.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift . .	14	14
Ordovician system		
Oneota dolomite	161	175
Cambrian system		
Trempealeau dolomite . . .	74+	249

Compton

The public water supply at Compton is obtained from a well 315 feet deep (originally 335) located in the SW¼ NW¼ sec. 11, T. 37 N., R. 1 E. No samples of drill cuttings from this well are on file at the State Geological Survey, but it is reported to be completed in sand and gravel.

In 1954 a new village well was constructed about 50 feet from the old west well and completed in sand and gravel at a depth of 334 feet. A partial set of drill cuttings is on file at the Survey.

Water-bearing sand and gravel probably is abundant below a depth of about 300 feet in parts of the area, particularly southeast of Compton. Although the potential of these deposits has not been proved, there appears to be little need for deep drilling in bedrock for industrial or public groundwater supplies.

Dixon

The public water supply at Dixon is obtained from deep wells penetrating the Galesville and Mt. Simon sandstones. Well 5 was drilled in 1945 to a total depth of 1700 feet, about 275 feet below the top of the Mt. Simon. The Galesville and Mt. Simon sandstones were then shot with nitroglycerin in an attempt to increase the yield. The well was cleaned out to a depth of 1472 feet, so no more than 50 feet of Mt. Simon sandstone is now exposed in the well. Most of the water is probably from the Galesville sandstone, with some from St. Peter sandstone and Trempealeau dolomite.

No important water-bearing sand and gravel deposits are known within economic reach of Dixon. The best possibilities for public water supply appear to be wells similar to No. 5, although the necessity of penetrating far below the base of the Galesville sandstone is questionable.

The geologic record that follows is based on a study of samples from Dixon city well 5. Location: SE¼ SE¼ sec. 32, T. 22 N., R. 9 E. Est. elev.: 660 feet. Study by M. P. Meyer.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift . .	8	8
Ordovician system		
Galena–Platteville dolomite . .	112	120
Glenwood sandstone and shale .	45	165
St. Peter sandstone and shale below	212	377
Shakopee dolomite	38	415
Oneota dolomite	160	575
Cambrian system		
Trempealeau dolomite . . .	155	730
Franconia dolomite and sandstone	100	830
Galesville sandstone	145	975
Eau Claire shale and sandstone .	450	1425
Mt. Simon sandstone	275+	1700

Franklin Grove

The public water supply at Franklin Grove is obtained from drilled wells that penetrate the Shakopee and Oneota dolomites and the New Richmond sandstone of the Prairie du Chien series. The well drilled in 1902 has a depth of 298 feet, 268 feet of which is in bedrock. Most of the groundwater probably comes from the Shakopee dolomite, which lies directly beneath the glacial drift at most places in this area.

The best future possibilities for public water wells are the Galesville sandstone, wells 650 to 800 feet deep, and the shallower dolomite formations where sufficiently fractured. As no important sand and gravel beds are known in the area, the prospects for high-capacity shallow wells are generally poor. The Shakopee dolomite is exposed to surface water at several places northwest of Franklin Grove and is only thinly covered with drift in the village.

Consideration should therefore be given to the hazard of groundwater pollution in this formation. Well specifications should call for casing and pressure grouting, at least to the New Richmond sandstone (estimated depth, 150 to 200 feet). This type of construction might require drilling to the Galesville sandstone, because casing and grouting the shallow dolomite probably would considerably reduce well yield.

The geologic record that follows is based on an interpretation of the driller's log of the Franklin Grove well 1. Near center NW¼ sec. 1, T. 21 N., R. 10 E. Est. elev.: 810 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift	30	30
Ordovician system		
Shakopee dolomite	150 est.	180 est.
New Richmond sandstone	25 est.	205 est.
Oneota dolomite	93+	298 est.

Harmon

The public water supply at Harmon is obtained from a series of drive points in sand and gravel, each reported to be about 32 feet deep. Prior to 1923 water was obtained from a 532-foot well drilled in dolomite, probably the Galena-Platteville.

The glacial drift is believed to be 150 to 175 feet thick in the Harmon area. It is mostly tight pebbly clay below a surficial cover of water-bearing sand and gravel. The actual thickness and potential of the shallow sands and gravels now being tapped at Harmon are unknown. There appears to be a good possibility that at some places in the Harmon area sand and gravel deposits occur within the glacial drift below a depth of about 100 feet. The probable occurrence of these deposits and the known occurrence of shallow sands and gravels suggest that deep drilling in bedrock for public water supplies will not be necessary.

Lee

The public water supply at Lee is obtained from a well 355 feet deep drilled in 1904 and completed in water-bearing sand and gravel. This well is located in the NW¼ SW¼ sec. 6, T. 38 N., R. 3 E., DeKalb Co.

The probable occurrence of very favorable water-bearing sands and gravels in one or more zones between 300 and 450 feet deep suggests that deep drilling in bedrock is probably unnecessary for expanded water development. The greatest concentration of water-bearing sand and gravel appears to lie principally west and southwest of Lee.

Paw Paw

The public water supply at Paw Paw is obtained from a drilled well 1018 feet deep, constructed in 1895. No drill cuttings were filed with the State Geological Survey, but a correlated driller's log is shown below. The well is open hole below about 454 feet, the base of the glacial drift. It probably taps water from the Oneota and Trempealeau dolomites and the Galesville sandstone. The low temperature of the water (54.2° F.) suggests that a large percentage may be from the Oneota and Trempealeau formations. Galesville water is likely to have a temperature of 56° F. in this area; water from the shallower dolomites is somewhat cooler.

Paw Paw appears to be well situated with respect to water-bearing sand and gravel deposits in the glacial drift. Data are lacking to indicate the potential of these beds, but they are known to lie generally below a depth of 250 feet. Consideration should be given to the testing and developing of these shallower sources in future development.

The geologic record that follows is based on an interpretation of the driller's log of the Paw Paw well. Location: SE¼ SE¼ sec. 10, T. 37 N., R. 2 E. Est. elev.: 928 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift	454	454
Ordovician system		
Oneota dolomite	136	590
Cambrian system		
Trempealeau dolomite	160 est.	750
Franconia shale, dolomite, and sandstone	135	885
Galesville sandstone	133	1018
Eau Claire dolomite, shale, and sandstone		below

Steward

The public water supply at Steward is obtained from an old drilled well about 100 feet deep, completed in water-bearing sand and gravel. Little additional information is available.

The thickness, extent, and potential of sand and gravel beds in the glacial drift here are unknown. The possibility that favorable water-bearing sand and gravel deposits occur is fair to good, particularly a mile or more east of the village where the greatest concentration of deep sand and gravel is likely. It is questionable whether it would be necessary to drill east of the village to find water-yielding sand and gravel.

Geologic conditions in bedrock formations at Steward are not known because of the probable presence of the Sandwich fault zone, which would cause the formations to be broken and distorted. The St. Peter sandstone may be missing, particularly southwest of the village. However, the Galesville sandstone, which is probably 600 to 700 feet deep on the southwestern side, should yield water, as do shallower dolomite formations where they contain open fractures.

Sublette

The public water supply at Sublette is obtained from a well drilled in 1898 to a depth of 752 feet. The well taps the St. Peter sandstone, into which it penetrates 152 feet. Some water probably enters the well from open cracks in the overlying Galena-Platteville dolomite, but the yield from this formation is unknown. If the casing is poorly seated in the top of the dolomite some water may seep down from shallower water-bearing sands and gravels and enter at the base of the casing.

Sublette is favorably situated with respect to the probable occurrence of water-bearing sand and gravel in the glacial drift, although the potential of the beds below a depth of about 200 feet is not known. Consideration should be given to testing and developing these shallower sources in future drilling for a public water supply.

The following geologic record is based on an interpretation of the driller's log of the Sublette well. Location: SE¼ SE¼ sec. 9, T. 19 N., R. 11 E. Est. elev.: 920 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Unconsolidated glacial drift . .	443	443
Ordovician system		
Galena–Platteville dolomite . .	157	600
St. Peter sandstone	152	752

West Brooklyn

Wells for the village water supply have been drilled in sand and gravel beds in the glacial drift and in the St. Peter sandstone, which lies directly below the unconsolidated drift. The most recent well was drilled in 1948 to a total depth of 650 feet, penetrating the sandstone bedrock 160 feet.

West Brooklyn is situated on high glacial moraine and over the northwestern flank of the ancient bedrock valley of the Rock River. Glacial drift thickness in the area is generally over 400 feet and locally as much as 500 feet. Much of the glacial drift is tight pebbly clay, although it contains some water-bearing sands and gravels, particularly below 300 feet. The potential of these is unknown, but it is probably adequate for village supply if wells are properly constructed. Silt and clay in the aquifers may limit their water-yielding potential.

Best possibilities for high-capacity wells in deep bedrock are in the Galesville sandstone below a depth of about 925 feet.

The following geologic record is based on study of drillings of village well 3, drilled in 1948. Location: approx. center W½ sec. 8, T. 37 N., R. 1 E. Est. elev.: 980 feet. Study by M. P. Meyer.

	Thickness feet	*Depth feet*
Pleistocene series		
Wisconsin glacial drift		
Till, brown, grading to sandy. .	109	109
Sand, coarse, and gravel, clayey.	22	131
Sand, fine to medium, clayey . .	9	140
Till, brown, with gray, lower part	146	286
Illinoian glacial drift		
Till, greenish, partly noncalcareous	7	293
Till, gray, calcareous	28	321
Sand and gravel, silty and clayey, generally cleaner near base .	105	426

Pre-Illinoian glacial drift		
Humus on noncalcareous clay, with sand and gravel below	21	447
Till, gray, very sandy, gravelly, calcareous	19	466
Sand, medium to very coarse, slightly silty	18	484
Till, yellow and gray, noncalcareous, with thin sand and gravel lower part	6	490
Ordovician system		
Glenwood sandstone, yellow, fine to medium, incoherent	17	507
St. Peter sandstone, light yellow, very fine to coarse, some silt, incoherent, red shale at base	143	650

PLANNING PRIVATE WATER WELLS

In practically all areas in Lee and Whiteside counties, wells for farms and rural homes should be located according to convenience and good sanitation, because geologic conditions are likely to be suitable for private water supplies at any site. The geology varies from place to place and controls the cost and type of well to be constructed. Testing in advance of construction of permanent wells is not usually necessary or practical in planning private water supplies, because drillers can complete a well in the shallowest suitable formation and adapt the well to this formation without advance testing. The suggestions that follow are meant to guide the planning of private water supplies in Lee and Whiteside counties. Based on the likelihood of finding water-bearing sand and gravel above bedrock, the counties are divided into three areas, from Area 1, the most favorable, to Area 3, the least (fig. 5).

Planning in Area 1

Most properties in Area 1 in Whiteside County are well situated for the construction of drive-point or small drilled wells in shallow sand and gravel. Drilled wells constructed with a metal screen at the bottom generally can be completed at depths not greater than 50 to 75 feet. Where wells are to be constructed at minimum cost, common drive points are a practical means of obtaining private supplies in the broad lowlands of Whiteside County. It is suggested that owners planning drive-point wells follow the suggestions of manufacturers and the State Department of Public Health for selecting dry sanitary locations.

In Lee County, lowland properties in Area 1 are well situated for drive-point or small drilled wells in shallow sand and gravel. Most wells need not be deeper than 50 to 75 feet. In the highlands of southern and southeastern Lee County, however, properties are classed in Area 1 because of the probable occurrence of sand and gravel deep in the drift, generally below 100 feet and in places below 300 feet. Because there is no shallow water-bearing sand and gravel suitable for drilled wells in the highlands, many farms have only large dug wells. Possibilities for finding suitable sand and gravel beds are generally excellent but owners should be prepared to penetrate 100 to 300 feet of tight pebbly clay.

Planning in Area 2

Wells drilled in Area 2 in Lee and Whiteside counties may or may not encounter deposits of suitable sand and gravel. It is suggested that drillers complete shallow screened wells in sand and gravel where these deposits are found adequate—otherwise case to bedrock. In the lowlands it is practical in some places to obtain water supplies with drive points. For this inexpensive type of well construction it may be desirable to test with a soil auger for the occurrence of water-bearing sand below soil.

Figure 6 shows the rock formation that probably lies directly beneath the glacial drift. Figure 3 indicates its water-yielding importance.

Planning in Area 3

Wells drilled for private water supplies in Area 3 penetrate bedrock at nearly all sites. Glacial drift is generally less than 65 feet thick and is not known to contain significant deposits of water-bearing sand and gravel. Figure 6 shows the bedrock formation that underlies the drift cover or is exposed where glacial drift is missing. Figure 3 indicates its water-yielding importance. Private water supplies are generally available from shallow bedrock with the exception of the Maquoketa formation where it is largely tight shale.

In many parts of Area 3 in Lee and Whiteside counties, dolomite lies close to the surface. This condition creates a hazard of polluted surface water entering the rock. Special care should therefore be taken in the construction of wells in shallow dolomite, particularly where the rock is covered by less than 30 feet of glacial drift or where bedrock is exposed within a few hundred feet of the well. Seepage from septic tanks is a common cause of local groundwater pollution in dolomite rock; a bacterial test is recommended before acceptance of a completed well. Where polluted water is found, it may be necessary to drill deeper, case, and grout with cement slurry.

The danger of distant pollution is not so great in groundwater from the St. Peter sandstone as it is in dolomite. Nevertheless, local pollution from septic lines is a hazard where the sandstone is covered by less than about 20 feet of drift. Under these conditions, wells should be located as far from seepage lines as possible.

PLANNING INDUSTRIAL AND MUNICIPAL WATER WELLS

Sound planning for industrial and municipal water wells requires that engineers and other planners recognize geologic and hydrologic conditions. Planning should be based on the best available information on water-yielding formations — their occurrence, thickness, depth, drilling characteristics, hole-sustaining abilities, and water-yielding potential. Rigid well specifications, made without adequate geologic and hydrologic data, have caused serious mistakes. As the water-yielding ability of most geologic formations is somewhat unpredictable, it may never be practical to draw fixed specifications for water wells without a test hole. If shallow well construction is not feasible, a test hole is generally impractical, and deep-well construction should be undertaken with a flexible drilling program. For example, if the Trempealeau dolomite is found abundantly creviced and is, therefore, a good source of groundwater, specifications should permit completion of the well without deeper drilling. If there is a strong possibility that water-bearing sand and gravel beds occur, these should first be tested with a small test hole.

Development of water supplies in sand and gravel beds is based partly on the premise that these shallow sources are probably the most economical, and partly on the fact that water from bedrock formations should be conserved for those areas where there is no alternative to deep drilling. Shallow water-bearing sands and gravels in Illinois are for the most part readily recharged by direct percolation or by indirect seepage. The deepest bedrock formations, on the other hand, particularly below the Maquoketa shale in Whiteside County and below the Oneota dolomite in Lee County, are not so readily recharged and are therefore much more subject to long-term overdevelopment.

As an aid to planning industrial and municipal water-supply programs, Lee and Whiteside counties have been divided here into three areas, as they were for private water supplies.

Planning in Area 1

In Area 1 deep drilling into bedrock is discouraged until the possibilities in water-bearing sand and gravel have been explored. Drilling information may indicate the existence of sand and gravel deposits, or their occurrence may appear very likely in view of favorable geologic history and conditions. Where large water supplies are involved, it is suggested that a test hole be drilled at the most convenient and sanitary location for a permanent well. Adequate testing can be done with a 2 to 4 inch rotary machine. This method enables a test of water quality and a pump test of the formation to be taken, although such a test has often been found unnecessary when the main purpose of the test hole is to determine the occurrence and thickness of a sand and gravel deposit.

At most locations in Area 1, a single test hole will suffice to indicate the occurrence of sand and gravel for industrial and small municipal groundwater development. As a general rule, test holes should penetrate to the top of the bedrock. Depth to bedrock in

Area 1 ranges from about 75 to nearly 600 feet, the greatest being in eastern Lee County. Testing the entire thickness of the drift provides the opportunity to complete a permanent well in the most desirable zone.

Planning in Area 2

Possibilities of finding sources of groundwater above bedrock in Area 2 are generally moderate. This area contains some water-bearing sands and gravels that have been proved by drilling, or geologic conditions are moderately favorable for their occurrence. Planning should take into account the distinct possibility that suitable sand and gravel sources do not occur within economic reach and that well construction in bedrock may be necessary.

A slim-hole test into the glacial drift for the occurrence of adequate sand and gravel deposits is probably desirable in most places. The drift of Area 2 is generally 40 to 150 feet thick. Where water-bearing beds are found to be of uncertain promise, testing other locations in the neighborhood may be desirable.

Planning in Area 3

The possibilities of finding sand and gravel beds suitable for industrial or municipal water supplies are slim in Area 3. This area has been proved to be barren of productive sand and gravel in some areas and is geologically unfavorable in others. Construction of wells in bedrock, without prior testing of shallow material, is justified in this area.

In at least one-third of Area 3, dolomite lies within 30 feet of the land surface; therefore the danger of pollution should be recognized. Surface casing in rock wells should be pressure-grouted to a safe depth wherever construction of the upper part of the well indicates the possibility of pollution.

A safe grouting depth is normally considered the depth to the shallowest impermeable or noncreviced rock formation, but factors such as drift thickness, amount of dolomite crevicing, and local concentration of pollution also should be considered.

SUMMARY OF GROUNDWATER POSSIBILITIES IN LEE COUNTY BY TOWNSHIPS

Hamilton Township (T. 19 N., R. 8 E.)

Depth to dolomite bedrock ranges from 75 feet in the northwestern part of Hamilton Township to about 340 feet beneath the uplands of sec. 36. Water-bearing sand and gravel beds are abundant, so good possibilities for industrial water wells exist in virtually all areas. These deposits occur directly beneath the soil at most places, except in the uplands of the extreme southeastern corner of the township where the shallow material is pebbly clay. In the flat plains, domestic private water supplies are generally available from drive-point or shallow drilled wells in sand and gravel. In the uplands of secs. 25, 35, and 36, drilled wells must penetrate as much as 100 to 150 feet of tight pebbly clay to tap buried water-bearing sands and gravels.

Silurian dolomite is believed to underlie glacial drift at nearly all well sites. It is generally water-yielding through open cracks. The top of the St. Peter sandstone is estimated to be about 720 feet deep in sec. 1 and about 1070 feet in sec. 31. The top of the Galesville sandstone is estimated to be about 1520 feet deep in sec. 1 and about 1660 feet in sec. 31.

East Grove Township (T. 19 N., R. 9 E.)

Depth to bedrock in East Grove Township possibly ranges from about 40 feet in the lowlands of sec. 3 to about 350 feet near the southwestern corner of sec. 31. Water-bearing sand and gravel beds are abundant, although they may be too thin for industrial water supplies in sec. 3 and vicinity. In the lowlands of the northern and northwestern parts of the township, sand and gravel beds lie directly beneath the soil, so private water supplies can be obtained with drive-point or shallow drilled wells. In the uplands of the central and southern parts, water-bearing sand and gravel beds are covered by as much as 100 to 200 feet of tight pebbly clay. The

best areas for testing for industrial wells in sand and gravel appear to be secs. 6, 7, 18, 19, 30 to 33, and 36.

Pennsylvanian bedrock, containing coal beds at many places, directly underlies the glacial drift except in parts of secs. 6, 7, 18, 19, and 29 to 32, where Silurian dolomite probably forms the top bedrock. Beds of the Pennsylvanian system are not generally favorable sources of groundwater. Wherever they occur below the drift, special effort should be made to obtain water from shallow deposits of sand and gravel.

The top of the St. Peter sandstone is estimated to be about 730 feet deep in sec. 2 and about 1150 feet in sec. 31. The top of the Galesville sandstone is estimated to be about 1450 feet deep at the southeastern corner of sec. 12 and about 1770 feet at the southwestern corner of sec. 31.

Pockets of inflammable methane gas are known to occur at various depths in the glacial drift in secs. 28, 31, 33, and 35, and they probably occur locally elsewhere. The gas can in some instances be developed for domestic uses, but its occurrence in water wells can be troublesome. Shallow gas is improbable in the lowlands of the north but is more likely in the uplands.

May Township (T. 19 N., R. 10 E.)

Thick glacial drift covers the bedrock throughout May township and contains water-bearing sand and gravel. Depth to bedrock ranges from about 150 feet at the lowest places in secs. 1 and 2 to about 450 feet near the southeastern corner of sec. 32. Beds suitable for private water supplies can be found at most locations, although it may in some places be necessary to drill through as much as 100 feet of tight pebbly clay to tap them. In the NW portion of sec. 6, water-bearing sand and gravel lying near the surface probably can be tapped with drive-point or shallow drilled wells. Opportunity for development of industrial water wells in sand and gravel beds appears to be good in most areas, with the possible exception of secs. 1 to 4 and 11 to 14.

Shale or shaly limestone probably directly underlies the glacial drift in most of secs. 5, 6, 7, 17, 18, 31, and 32. They are not favorable sources of groundwater. Silurian or Galena dolomite probably underlies the glacial drift in other places and may yield water through open cracks. The top of the St. Peter sandstone is estimated to be about 450 feet deep at the northeastern corner of sec. 1 and about 1100 feet at the southwestern corner of sec. 31. The top of the Galesville sandstone is estimated to be about 1150 feet deep at the northeastern corner of sec. 1 and about 1900 feet deep at the southwestern corner of sec. 31.

Pockets of inflammable methane gas, generally at least 200 feet deep, are present in the glacial drift in secs. 15, 16, and 21, and probably locally elsewhere. The gas in some places can be developed for domestic purposes, but it can be troublesome in developing water wells.

Sublette Township (T. 19 N., R. 11 E.)

Thick glacial drift covers the bedrock throughout Sublette Township. Depth to bedrock ranges from about 100 feet on lowlands in sec. 6 to a maximum of about 420 to 470 feet at high places in secs. 32 to 36. Shallow water-bearing sand and gravel beds are scarce, but conditions appear favorable for the occurrence of very promising deep water-bearing sand and gravel beds in the southern part of the township, particularly secs. 23 to 36. The water-bearing formations may be covered by 150 to 200 feet of tight pebbly clay. Where shallow sands or gravels are absent, it may be necessary to penetrate 150 feet or more of pebbly clay for private water supplies from drilled wells.

Dolomite directly underlies the glacial drift except in parts of secs. 24, 25, 26, 35, and 36, where St. Peter sandstone probably lies under the drift. In the old well at Sublette, the top of the St. Peter sandstone is about 600 feet deep. It lies at depths of about 400 feet at the northeastern corner of sec. 1 and about 850 feet at the southwestern corner of sec. 31. The top of the Galesville sandstone is estimated to be 950 feet at the northeastern corner of sec. 1 and 1600 feet at the southwestern corner of sec. 31.

Harmon Township (T. 20 N., R. 8 E.)

Depth to shale and dolomite bedrock in Harmon Township ranges from about 40 feet in sec. 6 to 215 feet in parts of secs. 23 to 26, 35, and 36. In the northern, southern, and western parts, water-bearing sand and gravel beds lie at or close to the surface. Private water supplies here are generally available from drive-point or shallow drilled wells. Water-bearing sand and gravel is also present at most other places, but east of Harmon the sands are generally capped by tight pebbly clay. Possibilities for private drilled wells in sand and gravel are generally good. The best possibilities for industrial wells in deeper and thicker sand and gravel beds appear to be in secs. 13, 14, 23 to 27, and 34 to 36.

Southwest of Harmon the glacial drift is probably directly underlain by Silurian dolomite, which is commonly water-yielding; northeast of Harmon the bedrock is probably Maquoketa shale, which is not generally considered a good source of groundwater. The top of the St. Peter sandstone is estimated to be about 330 feet deep in sec. 1, and about 850 feet deep in sec. 31. The top of the Galesville sandstone is estimated to be about 1080 feet in sec. 1 and about 1510 feet in sec. 31.

Marion Township (T. 20 N., R. 9 E.)

Depth to bedrock in Marion Township ranges from about 40 feet in parts of sec. 14, southwest of the Green River Ordnance Plant, to about 150 feet in the western part of secs. 19, 30, and 31. Shallow water-bearing sand and gravel, in many places suitable for drive-point wells, is abundant in most of secs. 29 to 36 and in the southern part of secs. 25 to 27. Elsewhere the possibilities for finding water-bearing sand and gravel below pebbly clay are generally good. The best possibilities for industrial wells in deeper sand and gravel appear to be in parts of secs. 1, 2, 9 to 12, 16 to 19, 30, and 31.

South of the Chicago, Burlington and Quincy Railroad, to the south line of the township, the glacial drift probably is underlain by Pennsylvanian bedrock containing coal, shale, and limestone beds that are not generally favorable groundwater sources. In most of secs. 6, 7, 8, 17, and 18, the top bedrock is probably Maquoketa shale, not considered a favorable source of groundwater. Elsewhere the top bedrock is Galena-Platteville dolomite, which may yield water through open cracks. Depth to St. Peter sandstone in the Green River Ordnance Plant well P-1, sec. 1, is 203 feet. It is estimated to be 680 feet deep in sec. 31. The top of the Galesville sandstone is 1015 feet deep at Green River Ordnance Plant well T-W-1, sec. 12. It is estimated to be 1530 feet in sec. 31.

Amboy Township (T. 20 N., R. 10 E.)

Depth to bedrock in Amboy Township reaches a maximum of about 240 feet in the uplands of sec. 35. In the flat lowland near the Green River, thin water-bearing sand and gravel beds lie directly beneath the soil. Drive-point or shallow drilled wells are locally practical, but most wells tap Galena-Platteville dolomite. In the uplands of secs. 24, 25, 35, and 36, the shallow material is mostly tight pebbly clay, but this is generally underlain by sand and gravel down to about 140 feet. The best possibilities for industrial wells in sand and gravel appear to be in parts of secs. 19, 30, 31, 32, and possibly in secs. 35 and 36.

In most of secs. 30 and 31, the bedrock below the glacial drift is probably Pennsylvanian coal, shale, and limestone, not generally considered favorable groundwater sources. In most of secs. 28, 29, 32, and 33, the bedrock is probably Maquoketa shale, which generally does not yield much water. Elsewhere the bedrock is Galena-Platteville dolomite, generally a suitable source of private water supplies.

The top of the St. Peter is 230 feet deep at Amboy city well 2. It is about 80 feet deep in the lowlands of sec. 1 and about 720 feet deep in the southwestern corner of the township. The top of the Galesville sandstone is 950 feet deep at Amboy well 2. It is about 780 feet deep in the lowlands of sec. 1 and about 1510 feet deep in the southwestern corner of the township.

Lee Center Township (T. 20 N., R. 11 E.)

Dolomite is exposed at many places in the western and northwestern parts of Lee Center Township. Elsewhere depth to bedrock varies, reaching a maximum of about 400 feet in the uplands near the southeastern corner of the township. Shallow sand and gravel beds are thick enough to supply water to drive-point or small drilled wells along the lowlands of the Green River, particularly in secs. 1 to 3 and 9 to 12. In secs. 5 to 8, much of the drift is thin tight pebbly clay over limestone. Here wells are either dug in the drift or drilled in dolomite to tap open cracks. In the uplands of the southeast, many drilled wells tap deep sand and gravel beds capped by as much as 200 to 300 feet of tight pebbly clay. Possibilities for industrial wells in sand and gravel are uncertain, but they are probably best in the shallow deposits of the northeast and in deep gravels in the extreme southeast.

The St. Peter sandstone probably underlies the glacial drift in secs. 1 to 4 and 10 to 14. Elsewhere the uppermost bedrock is probably Galena-Platteville dolomite. The top of the St. Peter sandstone is only 70 to 90 feet deep in the lowlands of the northeast, but it is about 500 feet deep in the uplands of the southwest. The top of the Galesville sandstone is estimated to be 650 feet deep in the lowlands of the northeast and 1200 feet deep in the uplands of the extreme southwest.

Nelson Township (T. 21 N., R. 8 E.)

Depth to dolomite and shale in Nelson Township reaches a maximum of about 160 feet in parts of secs. 24 and 26. Bedrock is exposed in secs. 2 and 3 and along the Rock River in secs. 10 to 12. Shallow water-bearing sand and gravel is widespread in secs. 15 to 17, 19 to 22, and 27 to 33, and locally elsewhere. In this area, conditions are generally suitable for drive-point wells as sources of private water supplies. Deeper or thicker deposits of water-bearing sand and gravel, suitable for industrial wells, may occur in parts of secs. 24, 25, 26, 34, and 35. North of the Rock River, in the higher land areas, the drift is generally less than 35 feet thick and not water-yielding.

Dolomite generally underlies the drift, but Maquoketa shale is the uppermost bedrock in secs. 6, 7, 17 to 21, 26 to 30, 33 to 36, and locally elsewhere. Where the shale is not water-yielding, wells could tap the underlying water-bearing dolomite.

The top of the St. Peter sandstone is estimated to be 245 feet deep in the uplands of the northeast and 450 feet deep beneath the lowlands in the southwest. The top of the Galesville sandstone is estimated to be about 970 feet deep in the northeast and about 1250 feet deep in the southwest.

South Dixon Township (T. 21 N., R. 9 E.)

Galena-Platteville dolomite is exposed over wide areas near Dixon. The maximum thickness of drift cover is about 150 feet (southern sec. 18 and northern sec. 19). In the southern half of the township, the glacial drift contains scattered deposits of sand and gravel suitable for private water supplies, but in the northern half the drift is generally thinner and tighter. Wherever drilling fails to find water-bearing sand or gravel, private water supplies probably are available from open cracks in the underlying dolomite or from the St. Peter sandstone, which lies below the drift in the northeast. South Dixon Township is not known to contain water-bearing sand and gravel beds suitable for even small industrial development, but such beds may occur in secs. 18, 19, or 20, and locally elsewhere.

St. Peter sandstone is directly below the drift in secs. 9 to 12 and in parts of secs. 1 to 4. The top of the St. Peter is probably about 350 feet deep in the southwestern corner. The top of the Galesville sandstone is estimated to be 800 feet deep in the northeastern corner and about 1100 feet deep in the southwestern corner.

Nachusa (South) and China (South) Townships (T. 21 N., R. 10 E.)

Dolomite and sandstone crop out in secs. 2, 3, 4, 12, 19, and 31, but lie about 165 feet deep along the southern edge of secs. 31 and 32. Most of the drift is tight and

does not yield water. The only possible locations of sand and gravel beds suitable for even small private water wells seem to be in sec. 32 and the southern part of sec. 31. Water-bearing St. Peter sandstone probably underlies glacial drift in the northeastern half of the township (most of secs. 4 to 6, 9, 10, 13, 14, and 24). Elsewhere the bedrock is Galena-Platteville dolomite, which generally yields water through open cracks. In the southwestern corner of the township the top of the St. Peter sandstone is about 250 feet deep. The top of the Galesville sandstone is estimated to be 650 feet deep at Franklin Grove and 1000 feet deep east of Eldena.

Bradford Township (T. 21 N., R. 11 E.)

The glacial drift is generally thin in Bradford township. Sandstone or limestone reaches a maximum depth of 85 to 100 feet in the southeastern part (secs. 25 and 34 to 36). St. Peter sandstone is exposed in secs. 28, 32, and 33, and probably elsewhere. Only along the Green River lowlands in the southeast is shallow water-bearing sand and gravel likely to be abundant. In secs. 35 and 36, it is generally thick enough to permit drive-point wells for private water supplies. To the north and west, however, the possibility of finding such beds is poor. Water-bearing St. Peter sandstone underlies the drift in most of the southwestern part, so possibilities there are good for water supplies from wells drilled 75 to 150 feet deep. In secs. 1 to 15 and 22 to 26, the St. Peter is missing and the shallow bedrock is dolomite, probably suitable for private water supplies.

The top of the Galesville sandstone is estimated to be about 625 feet deep near the northeastern corner of the township and about 775 feet deep in the southwestern corner.

Palmyra Township (T. 22 N., R. 8 E.)

The glacial drift is generally very thin in Palmyra township. Dolomite crops out in most sections and is nowhere likely to be more than 50 feet deep. No deposits of water-bearing sand and gravel are known, although they may occur locally. Most drilled wells penetrate the dolomite and tap water from open cracks.

The top of the St. Peter sandstone is estimated to be 150 feet deep in the low areas of the northeast (sec. 13) and 375 feet deep at Prairieville in the southwest. The top of the Galesville sandstone is estimated to be 825 feet deep in sec. 13 and 1100 feet deep at Prairieville.

Dixon Township (T. 22 N., R. 9 E.)

The glacial drift is generally thin in Dixon township. Dolomite and sandstone are exposed in most sections and are probably nowhere deeper than about 50 feet. Water-bearing sand and gravel beds are scarce, although they occur locally. Sands along the Rock River Valley are generally too thin for groundwater development. Most wells penetrate St. Peter sandstone or Galena-Platteville dolomite.

Although St. Peter sandstone underlies the drift at many places northeast and east of Dixon, it is probably 75 to 125 feet deep at the western edge. The top of the Galesville sandstone is estimated to be 475 feet deep near Grand Detour and 950 feet deep near the western edge of Dixon.

Nachusa (North) and China (North) Townships (T. 22 N., R. 10 E.)

The glacial drift is generally 5 to 50 feet thick in this area. In portions of secs. 30 and 31, bedrock is buried to a maximum depth of about 150 feet. In this area water-bearing sands and gravels of limited potential are likely to occur in the lower part of the drift. Elsewhere these deposits are scarce and localized, except for shallow sands in the Rock River Valley in secs. 18 and 19 that are probably too thin for important groundwater development.

Most of the shallow bedrock in the western half of the township is water-bearing St. Peter sandstone. In the eastern half, the bedrock is Prairie du Chien dolomite. The dolomite at most locations yields water through open cracks.

The top of the Galesville sandstone is estimated to be 500 feet deep near Grand Detour and 650 to 800 feet deep in the uplands near Franklin Grove.

Ashton Township (T. 22 N., R. 11 E.)

Limestone and sandstone are generally less than 35 to 50 feet deep in Ashton Township and are exposed at several places in the east and north. Water-bearing sand and gravel beds in the drift are scarce. Most wells are large shallow dug wells or are drilled into Prairie du Chien dolomite, which yields water through open cracks. The top of the Galesville sandstone is estimated to be 650 to 725 feet deep near Ashton.

Brooklyn Township (T. 37 N., R. 1 E.)

The glacial drift is uncommonly thick in Brooklyn Township. Sandstone and dolomites probably range in depth from about 150 feet along the northern edge of sec. 6 to 525 to 575 feet in the uplands of secs. 13 to 16, 23 to 27, and 35. In these areas the highlands of the Bloomington moraine probably lie directly over the ancient channel of the Rock River. Widespread deposits of water-bearing sand and gravel are believed to lie within the drift at most places, except in the northwestern and southeastern corners. Many of the apparently promising water-bearing deposits lie below 250 to 300 feet; they appear to have industrial water possibilities. Shallower and less-extensive sands and gravels, suitable for private water wells, commonly occur 150 to 250 feet deep. The upper 150 feet of the drift is very tight.

Water-bearing St. Peter sandstone probably underlies the glacial drift in most places except in secs. 1, 12, 13, 24, and 25, and along the western edge of secs. 7, 18, 19, and 30. There the top bedrock is probably dolomite, which yields water through open cracks.

The top of the Galesville sandstone is estimated to be 800 feet deep at Compton and about 1050 feet deep at the southwestern corner of the township.

Wyoming Township (T. 37 N., R. 2 E.)

The bedrock is deeply buried by glacial drift throughout most of Wyoming Township. Dolomite and sandstone range from 50 feet deep near the southeastern corner to 500 to 575 feet deep in the center and northeast. There seems to be 500 feet or more of glacial drift in secs. 1, 2, 11, 12, and 14 to 21. In this area the higher parts of the Bloomington moraine probably overlie the ancient channel of the Rock River. Scattered information on deep drilling in the lower half of the drift indicates the existence of widespread water-bearing sand and gravel deposits which appear to have an industrial potential. Favorable deposits are likely to be found at most areas with the possible exception of the southern part of secs. 31 to 36, where the drift thins rapidly to the south. In the upland areas it may be necessary in some places to penetrate 100 to 150 feet of tight pebbly clay and silt before striking sands suitable for private water supplies.

Although the glacial drift apparently has water-yielding potential, the underlying bedrock is also generally water-yielding. The dominant rock is probably dolomite, except in a narrow belt along the southern edge of secs. 25 to 30 and along the northern edge of secs. 31 to 36, where the top bedrock is probably St. Peter sandstone.

The top of the Galesville sandstone is 885 feet deep at Paw Paw. The formation is slightly above sea level through most of the township except in the extreme northeast, where it is probably 25 to 50 feet below sea level, and in the northwest, where it is about 100 feet above sea level.

Pockets of inflammable methane gas occur in the glacial drift in secs. 9, 17, 20, and 30, and probably locally elsewhere. The gas can in some instances be developed for domestic purposes, but its occurrences in water wells can be troublesome.

Viola Township (T. 38 N., R. 1 E.)

Depth to sandstone and dolomite in Viola Township ranges from about 25 to 40 feet in the northern part of secs. 3 and 4 to about 400 feet in sec. 36. Shallow water-bearing sand and gravel beds are abundant in the lowlands of the northern half of the township and in secs. 19, 20, and 30. These deposits yield water to drive-point wells at many places but are locally too thin for extensive development. The best areas for industrial groundwater development in sand

and gravel beds appear to be in the uplands of the southeast. The glacial drift here contains widespread sand and gravel deposits below tight pebbly clay, but their potential has not been proved. Conditions for private water supplies are generally good.

The bedrock below the glacial drift in the southwestern third of the township is water-bearing St. Peter sandstone. Elsewhere the rock is probably Prairie du Chien dolomite.

The top of the Galesville sandstone is about 100 to 150 feet above sea level and about 750 to 850 feet deep in the uplands of the south.

Willow Creek Township (T. 38 N., R. 2 E.)

Depth to dolomite in Willow Creek Township ranges from about 50 to 75 feet in sec. 6 to about 575 to 600 feet in the uplands in secs. 25, 35, and 36. This area is believed to have the thickest cover of glacial drift in Illinois. Water-bearing sand and gravel deposits are abundant in the drift throughout most of the township. In the lowlands in secs. 5 to 8, water-bearing sand and gravel is shallow and generally thin, but private water supplies can be developed at many places by drive points. The best possibilities for industrial water supplies in sand and gravel appear to be in the uplands of the eastern and southern halves of the township. The better water-bearing beds there are generally below a depth of 175 feet and are covered with tight pebbly clay. Full industrial water potential is not known because there has been little drilling below 250 feet. Private water supplies are available from wells drilled in the uplands, but it is necessary locally to drill 100 feet or more through tight pebbly clay to tap the water-bearing sands beneath.

The bedrock is probably Prairie du Chien dolomite to the west and Trempealeau dolomite to the east. These formations are likely to be water-yielding through open cracks. The top of the Galesville sandstone is probably about at sea level except in the west, where it is about 100 feet above sea level, and in the lowlands of the northwest, where it is about 735 feet deep.

Pockets of inflammable methane gas occur in the glacial drift in sec. 25 and probably locally elsewhere. The gas can in some instances be developed for domestic purposes, but in water wells it can be troublesome. Shallow gas is improbable in the lowlands of the northwest but more probable in the uplands of the eastern half of the township.

Reynolds Township (T. 39 N., R. 1 E.)

Dolomite and sandstone in Reynolds Township are exposed in a rock quarry in sec. 26. This bedrock is as much as 275 to 300 feet deep in parts of secs. 1, 2, 3, 11, and 12. Shallow water-bearing sand occurs at many places in secs. 2 to 4, 10 to 14, 25 to 27, and 32 to 36. Although these deposits are likely to be thin, private water supplies are locally available from shallow drive points. In the western part of the township most private water supplies are from large dug wells or wells drilled in dolomite. Water-bearing sand and gravel beds suitable for industrial supplies are not widespread in this township. The upper bedrock in most of the township is likely to be dolomite, generally water-yielding through open cracks. In parts of secs. 2, 3, 11, and 12, water-bearing St. Peter sandstone may be found.

The top of the Galesville sandstone is estimated to be 100 feet above sea level in most of the township, but slightly lower in the extreme northeast, secs. 1, 2, 3, and 12. It is probably about 700 feet deep in the center of the township (southwestern corner of sec. 15).

Alto Township (T. 39 N., R. 2 E.)

Depth to dolomite and sandstone in Alto Township is about 60 to 80 feet along the western edge of secs. 30 and 31 and near the northern edge of secs. 5 and 6. But bedrock is at least 550 feet deep in the southern part of sec. 35 and is generally deeper than 400 feet in a north-south belt through secs. 1, 2, 11, 15, 22, 26, 27, 34, and 35. This area of thick glacial drift appears to be well suited to industrial water wells, as sand and gravel deposits are believed to be widespread in the lower half of the drift, generally deeper than 200 feet. There has

not been enough deep drilling to test the industrial potential. In the uplands of the eastern half of the township, the upper 100 feet of drift is generally tight; hence in some areas water wells for private supplies are drilled 125 to 250 feet deep to penetrate suitable sands. Along the western edge of the township, secs. 5 to 8, 17 to 20, 30, and 31, shallow water-bearing sand is common. Where it is at least 20 feet thick, this shallow sand may be suitable for drive-point wells for private water supplies.

The St. Peter sandstone and a number of dolomite beds directly underlie the drift of this township. The sandstone is water-bearing and limited mainly to secs. 2, 7, 8, 11, 14 to 18, 21, 22, 23, 26, and 27. The dolomite formations are likely to yield groundwater through open cracks at most locations. The top of the Galesville sandstone is estimated to be 700 to 750 feet deep at Steward, deeper to the east, and as shallow as 675 to 700 feet in the southwestern corner of the township (sec. 31).

SUMMARY OF GROUNDWATER POSSIBILITIES IN WHITESIDE COUNTY BY TOWNSHIPS

Erie Township (T. 19 N., R. 3 E.)

The depth to bedrock in Erie Township ranges from less than 50 feet in secs. 21 to 24 to 220 to 300 feet near the north line of secs. 1, 2, and 3. Shallow water-bearing sand and gravel is abundant throughout the township. Drive-point or shallow drilled wells are generally practical for private water supplies. Where sand and gravel is locally thin, as in parts of secs. 21 to 25, drilled wells may have to penetrate 10 to 40 feet into limestone to tap open water-bearing cracks. Excellent industrial water possibilities exist in deep sand and gravel in the northeast, including all of secs. 1, 2, and 3.

Silurian dolomite, which underlies unconsolidated material throughout the township, may yield water from open cracks. The top of the St. Peter sandstone is estimated to be 900 feet deep in the north and 1000 feet deep in the south. The top of the Galesville sandstone is estimated to be 1620 feet deep in the north and 1650 feet in the south.

Portland Township (T. 19 N., R. 4 E.)

Dolomite in Portland Township is exposed near the Rock River in secs. 18 and 19. The maximum depth to bedrock is about 320 feet near the southern line of sec. 13. Unconsolidated material is generally thicker than 250 feet in secs. 5, 9, 10, 13, 14, and 24, an area underlain by the old valley of the Mississippi River. Shallow water-bearing sand and gravel is abundant in most sections, except south and southwest of Spring Hill, where shallow material is locally pebbly clay. Conditions are generally good for drive-point or shallow drilled wells for private water supplies. The best geologic conditions for industrial water wells are probably in the areas of thick glacial drift, where deep water-bearing sand and gravel is believed to occur. Industrial water possibilities are also good elsewhere.

Silurian dolomite probably underlies unconsolidated material throughout the township. It may yield water from open cracks. The top of the St. Peter sandstone is estimated to be about 950 feet deep in the north, about 1060 feet deep in the south. The top of the Galesville sandstone is estimated to be about 1600 feet deep in the northeast and about 1660 in the southwest.

Prophetstown Township (T. 19 N., R. 5 E.)

Depth to dolomite beneath the sand plain in Prophetstown Township ranges from about 20 to 30 feet in NE¼ sec. 1 to about 300 feet in secs. 19, 29, 32, and 33. The glacial drift is more than 150 feet thick in most of the southwestern half of the township and probably is favorable for industrial water wells in deep sand and gravel. Shallow water-bearing sand and gravel is abundant throughout the township; drive-point or shallow drilled wells are practical for private water supplies at most locations.

Silurian dolomite probably underlies drift throughout the township and may yield water from open cracks. The top of the St. Peter sandstone is estimated to be 1020 feet deep in the north and 1070 feet deep in the south. The top of the Galesville sandstone is estimated to be 1595 feet deep in the north and 1620 feet deep in the south.

Tampico Township (T. 19 N., R. 6 E.)

Depth to dolomite in Tampico Township generally ranges from less than 60 feet in secs. 1 to 12 to about 240 feet in the southwest corner of sec. 31. Shallow water-bearing sand and gravel is abundant throughout the township. Drive-point or shallow drilled wells are practical for private water supplies at most locations. Geologic conditions appear good for the construction of industrial water wells in deeper sand and gravel in the southern half of the township, where the glacial drift is generally more than 60 feet thick. The best conditions for industrial sand and gravel wells are probably in secs. 19, 20, and 28 to 34.

Silurian dolomite is the top bedrock throughout the township and may yield water from open cracks. The top of the St. Peter sandstone is estimated to be 1000 feet deep in the north and 1040 feet deep in the south. The top of the Galesville sandstone is estimated to be 1520 feet deep in the extreme northeast and 1660 feet deep in the extreme south.

Hahnaman Township (T. 19 N., R. 7 E.)

Depth to dolomite in Hahnaman Township ranges from probably less than 40 feet in the NW¼ sec. 6 to about 200 to 220 feet beneath the sand plain of secs. 11, 14, 23, 25, 26, 35, and 36. Shallow water-bearing sand and gravel is abundant throughout the township. Drive-point or shallow drilled wells are practical for private water supplies at most locations. Conditions appear good for the construction of industrial water wells in deeper sand and gravel in most of the township, with the possible exception of parts of secs. 1, 6, and 7, where sand and gravel may be locally thin.

Silurian dolomite underlies unconsolidated material throughout the township and may yield water from open cracks. The top of the St. Peter sandstone is estimated to be 850 feet deep in the northeastern corner of the township and 1050 feet in the south. The top of the Galesville sandstone is estimated to be 1525 feet deep in the northeastern corner of the township and 1660 feet in the south.

Cordova Township (T. 20 N., R. 2 E.)

Dolomite is exposed in Cordova Township on the edge of the Garden Plain uplands in sec. 2. It has a maximum depth of about 300 feet in sec. 23 and the southern half of secs. 24 to 26. Shallow water-bearing sand and gravel is abundant in the lowlands, where conditions are generally good for the use of drive-point or shallow drilled wells for private water supplies. Geologic conditions appear good for the construction of industrial water wells in deeper sand and gravel in most of the SW¼ sec. 13 and secs. 14, 23 to 26, 35, and 36, where depth to bedrock is generally more than 100 feet.

In secs. 1, 2, 11, 12, and the NE¼ sec. 13, most of the unconsolidated material is tight pebbly clay. Where sand and gravel is absent, private water wells are drilled 10 to 80 feet into Silurian dolomite. This dolomite probably underlies drift throughout the township and yields water at most locations from open cracks. The top of the St. Peter sandstone is estimated to be 820 feet deep in the lowlands of the north and 875 feet beneath the lowlands of the south. The top of the Galesville sandstone is estimated to be 1600 feet deep beneath the lowlands.

Newton Township (T. 20 N., R. 3 E.)

Dolomite is exposed in Newton Township near the center of the south line of sec. 16 on the edge of the Garden Plain upland. Its top has a maximum depth of about 300 feet. The thickest unconsolidated material is beneath the lowlands of the southwest (southern half sec. 30, sec. 31, and southwestern half sec. 32). Shallow water-bearing sand and gravel is abundant in most lowland areas; hence conditions are suitable for drive-point and shallow drilled wells. The best possibilities for industrial water wells in deeper sand and gravel appear to be in secs. 25 to 36 and along the southern edge of secs. 19 to 24.

On the Garden Plain upland, secs. 1 to 18, the glacial drift is largely pebbly clay and is generally thinner than 75 feet. Where sand and gravel is absent, water wells penetrate 10 to 50 feet into Silurian dolomite and tap water from open cracks. The top of the St. Peter sandstone is estimated to be

940 feet deep beneath the uplands of the north and 900 feet deep in the south.

Fenton Township (T. 20 N., R. 4 E.)

Bedrock is exposed in Fenton Township on the edge of the Garden Plain upland west of Fenton. It has a maximum depth of about 300 feet in the southern half of sec. 30 and in secs. 31 and 32. Shallow water-bearing sand and gravel is abundant beneath the lowlands with the exception of areas north of Fenton, where shallow material is likely to be silt and fine sand. Drive-point wells and shallow drilled wells in sand and gravel are practical at most lowland sites. The best possibilities for industrial wells in deeper sand and gravel appear to be in secs. 29 to 32 and the SW¼ sec. 34, where the unconsolidated material is generally thicker than 100 feet.

On the Garden Plain upland the glacial drift is generally thinner than 75 feet and contains only scattered deposits of water-bearing sand and gravel. Many wells penetrate 10 to 50 feet into Silurian dolomite, which lies beneath the drift throughout the township.

The top of the St. Peter sandstone is estimated to be 850 feet deep in the northeastern corner and 900 feet deep in the southwest. The top of the Galesville sandstone is estimated to be 1500 feet deep in the northeastern corner and about 1610 feet deep in the southwest.

Lyndon Township (T. 20 N., R. 5 E.)

The depth to dolomite in Lyndon Township ranges from less than 25 feet in secs. 1, 2, 5, 11, and 12 to about 200 feet in the eastern half of sec. 31 and the western half of sec. 32. Shallow water-bearing sand and gravel is abundant in the township. Except where bedrock is too near the surface, conditions are generally good for drive-point or shallow drilled wells in sand and gravel. The best areas for prospecting for deeper sand and gravel, suitable for industrial water wells, appear to be secs. 7 and 17 to 34, where depth to bedrock is generally more than 50 feet. The glacial drift may be entirely pebbly clay in some places in the NW¼ sec. 3 and NE¼ sec. 4. Where sand and gravel is absent it may be necessary to drill 75 to 150 feet into dolomite for private water supplies from small-diameter wells.

Silurian dolomite underlies unconsolidated material throughout the township and may yield water from open cracks. The top of the St. Peter sandstone is estimated to be 1475 feet deep in the northeast and 1600 feet in the southwest.

Hume Township (T. 20 N., R. 6 E.)

Depth to dolomite ranges in Hume Township from probably less than 35 feet at places in secs. 23 to 36 to about 60 feet in the Rock River lowland in the western part of the township. Shallow water-bearing sand and gravel probably occur in all areas. Conditions appear generally favorable for drive-point or shallow drilled wells in sand and gravel for private water supplies. Where the glacial drift is too thin for sand and gravel wells, water is generally available from open cracks in Silurian dolomite, which directly underlies the sand plain throughout the township. The best area for industrial water wells in deeper sand and gravel appears to be near the Rock River in the western part of the township.

The top of the St. Peter sandstone is estimated to be 720 feet deep in the northeast and about 1025 feet along the southern edge. The top of the Galesville sandstone is estimated to be 1440 feet deep in the northeastern corner and about 1570 feet in the southwestern corner.

Montmorency Township (T. 20 N., R. 7 E.)

Depth to solid bedrock in Montmorency Township is less than 35 feet in places in secs. 17 to 20, 29, and 30 and commonly less than 50 feet in secs. 1, 12, 13, and 24. Dolomite is deepest, generally 100 to 150 feet, in secs. 15, 22, 23, 26, 27, 34, and 35. The best conditions for industrial water wells in sand and gravel probably occur in a north-south belt that includes secs. 3, 4, 9, 10, 14 to 16, 21 to 23, 26 to 28, and 32 to 35. Depth to limestone is likely to be at least 60 feet in this belt. Much of the unconsolidated cover is water-bearing sand

and gravel, which is abundant throughout the township. Drive-point or shallow drilled wells in sand and gravel are practical for private water supplies. It will probably not be necessary to drill into Silurian dolomite at any location.

The top of the St. Peter sandstone is estimated to be 400 feet deep in the northeastern corner and 1030 feet in the southwest. The top of the Galesville sandstone is estimated to be 1250 feet deep in the northeastern corner and 1530 feet in the southwestern corner.

Albany Township (T. 21 N., R. 2 E.)

Bedrock is exposed in the lowlands around Albany. It has a maximum depth of about 150 feet near the southwestern corner of sec. 35. Water-bearing sand and gravel is abundant in the lowlands, and geologic conditions there are generally suitable for drive-point or shallow drilled wells. Beneath the higher lands, limestone is thinly covered by generally tight pebbly clay. In this area wells drilled for private water supplies penetrate Silurian dolomite, which probably underlies the glacial drift everywhere and which may yield water from open cracks. There appears to be some danger of pollution in limestone near Albany. The chance of finding deep sand and gravel suitable for industrial water wells appears to be most favorable in SW¼ sec. 35.

The top of the St. Peter sandstone is estimated to be 800 feet deep beneath the lowlands in the north and 820 feet deep beneath the lowlands in the south. The top of the Galesville sandstone is estimated to be 1540 feet deep in the north and 1585 feet deep in the south.

Garden Plain Township (T. 21 N., R. 3 E.)

Dolomite is exposed locally along the edges of the Garden Plain upland. It has a maximum depth of about 280 feet in the northern corner, near East Clinton. The best possibilities for industrial water wells in deep sand and gravel appear to be in secs. 4, 5, 8, and the western part of sec. 9. In the uplands the depth to bedrock is generally less than 75 feet, and the cover is mostly tight pebbly clay with local water-bearing sand and gravel. Where water-bearing sand and gravel is absent on the uplands, private wells penetrate into Silurian dolomite. This dolomite underlies glacial drift everywhere but in the Mississippi Valley, where shale probably underlies valley fill. The dolomite will yield water through open cracks at most places.

The top of the St. Peter sandstone is estimated to be 720 feet deep beneath the lowlands of sec. 1 and 975 feet deep beneath the uplands of the south. The top of the Galesville sandstone is estimated to be 1450 feet deep beneath the lowlands of sec. 1 and 1650 feet deep beneath the uplands of the south.

Union Grove Township (T. 21 N., R. 4 E.)

Bedrock in Union Grove Township is exposed east of Cattail Slough in sec. 21 and in northern sec. 12. It has a maximum depth of about 200 feet in SW¼ sec. 36. Much of the township east of Cattail Slough has a rolling surface of glacial drift, generally tight pebbly clay. Water-bearing sand and gravel is probably abundant along the east line of secs. 13, 24, 25, and 36, where depth to bedrock is generally more than 100 feet. Here possibilities appear good for industrial water wells in sand and gravel. In the lowlands of Cattail Slough the unconsolidated material is probably mostly fine sand and some silt to a depth of 40 to 50 feet. Good private water wells in sand can be constructed at most sites in this area. Where water-bearing sand and gravel is absent in the drift of the higher lands, water supplies are generally obtainable from the Silurian dolomite, which underlies glacial drift throughout the township.

The top of the St. Peter sandstone is estimated to be 800 feet deep in sec. 1 and 870 feet deep in the south. The top of the Galesville sandstone is estimated to be 1520 feet deep in sec. 1 and 1580 feet deep in the south.

Mount Pleasant Township (T. 21 N., R. 5 E.)

Dolomite is exposed north of Morrison,

whereas in the southwestern part of Mount Pleasant township it is covered by at least 100 feet of glacial drift. The best areas for water-bearing sand and gravel suitable for industrial wells appear to be secs. 3, 9, 16, 30, W½ sec. 31, and S½ secs. 19 and 20. There is probably water-bearing sand and gravel in the lowlands of Rock Creek Valley, and drive-point or shallow drilled wells may be constructed for private water supplies. North of the Chicago and Northwestern Railroad the dolomite is generally covered by pebbly clay containing only scattered water-bearing sands. South of the railroad, water-bearing sand and gravel is likely to occur below the pebbly clay at depths of 20 to 40 feet. Where sand is absent, water supplies are generally available from open cracks in the Silurian dolomite, which underlies glacial drift throughout the township.

The top of the St. Peter sandstone is 770 feet deep at Morrison city well 1. It is estimated to be 790 feet deep in sec. 1 and 875 feet deep in sec. 36. The top of the Galesville sandstone is 1485 feet deep at Morrison city well 1, about the same depth beneath the higher lands of sec. 1 and about 1530 feet deep in sec. 31.

Hopkins Township (T. 21 N., R. 6 E.)

Bedrock is exposed along Elkhorn Creek near Emerson in Hopkins Township. It has a maximum depth of about 100 feet along the lowlands near Como and locally beneath the higher uplands of the northern part. Shallow water-bearing sand and gravel is abundant in the lowlands of secs. 23 through 36. Much of this southern area is suitable for drive-point or shallow drilled wells in sand and gravel. Where the dolomite is 40 or more feet deep this sand and gravel should be suitable for industrial water wells.

In secs. 1 to 22 the unconsolidated material is mostly tight pebbly clay, with only scattered thin water-bearing sands. Where sand and gravel is absent, drilled wells penetrate dolomite and tap water from open cracks. The Silurian dolomite probably underlies the glacial drift throughout the township, although in extreme northeastern areas it is probably less than 40 feet thick in many locations. Drilled wells should not penetrate deeply into the shale below dolomite unless the intention is to drill several hundred feet to test deeper formations.

The top of the St. Peter sandstone is estimated to be 600 feet deep in sec. 1 and 840 feet deep in sec. 31. The top of the Galesville sandstone is estimated to be 1200 feet deep in sec. 1 and 1510 feet in sec. 31.

Sterling-Coloma Township (T. 21 N., R. 7 E.)

Depth to dolomite and shale ranges from less than 20 feet, in the lowlands of Elkhorn Creek in the northern part of Sterling-Coloma Township and at the Rock River near Lawrence Park, to about 110 to 150 feet in the southern part of secs. 33 and 34. South of Rock River, and in sec. 19, shallow water-bearing sand and gravel is abundant and conditions are generally favorable for drive-point and shallow drilled wells. In the southern tier of sections, particularly 32 to 35, the sand and gravel is generally more than 50 feet thick and appears favorable for industrial water wells. North of the Rock River, except in sec. 19 and in the lowlands of Elkhorn Creek, the drift is mostly tight pebbly clay with some water-bearing sands. Shale and shaly dolomite underlie glacial drift in most of secs. 1 to 5, 8 to 12, and near the Rock River east of Rock Falls. Where water-bearing sand and gravel is missing, it is often necessary to drill into dolomite 30 to 80 feet below the shale in order to obtain private water supplies with small wells. Silurian dolomite below the drift cover in secs. 6 and 7 should yield groundwater to shallow drilled wells.

The top of the St. Peter sandstone is 682 feet deep at Lawrence Brothers Manufacturing Co. well 2, Sterling. It is estimated to be 400 feet deep in sec. 1 and 730 feet in sec. 31. The top of the Galesville sandstone is 1437 feet deep at Northwestern Steel and Wire Company well 1, Sterling. It is estimated to be 1130 feet deep in sec. 1 and 1470 feet in sec. 31.

Fulton Township (T. 22 N., R. 3 E.)

Bedrock is exposed around the flank of

the uplands at Fulton. It has a maximum depth of about 300 feet in the Mississippi bottomlands in parts of secs. 1, 12, 13, 14, 23, 24, 26, 27, 33, and 34. Shallow water-bearing sand and gravel deposits are abundant in the lowlands throughout the township and are generally suitable for drive-point or shallow drilled wells for private water supplies. In scattered upland areas, such as at Fulton and in parts of secs. 24, 35, and 36, the drift may be mainly tight pebbly clay, but in these areas groundwater is generally available from shallow limestone below the drift. There is some danger of pollution near Fulton because the dolomite crops out extensively.

The best possibilities for industrial water wells in sand and gravel appear to be in most of secs. 1, 11 to 16, 23, 24, 26, 27, and 32 to 34. In these areas depth to bedrock is generally more than 175 feet.

The top of the St. Peter sandstone is 690 feet deep at Fulton city well 3. It is estimated to be 600 feet deep in the extreme northern part and 720 feet in the extreme southern part. The top of the Galesville sandstone is 1400 feet deep at Fulton city well 3. It is estimated to be 1300 feet deep in the extreme northern part and 1475 in the extreme southern part.

Ustick Township (T. 22 N., R. 4 E.)

Dolomite is exposed at numerous localities in the northern half of Ustick Township. The maximum depth is about 300 feet in the extreme western part of secs. 6 and 7 in the Mississippi bottomlands. Most of the township lies in an area of tight pebbly clay. Where good sand and gravel deposits are missing, wells penetrate limestone to tap open water-bearing cracks. Silurian dolomite probably underlies drift throughout the township except in parts of the Mississippi bottomlands.

The best possibilities for industrial water wells in sand and gravel appear to be in the lowlands of the Mississippi Valley (W½ secs. 6 and 7), where the bedrock is at least 150 feet deep.

The top of the St. Peter sandstone is estimated to be 760 feet deep beneath the uplands of sec. 1 and 800 feet beneath the uplands of sec. 31. The top of the Galesville sandstone is estimated to be 1350 feet deep in sec. 1 and 1550 feet deep in sec. 31.

Clyde Township (T. 22 N., R. 5 E.)

Dolomite in Clyde Township is exposed in places in the east, west, and north. It has a maximum depth of about 200 feet in sec. 34. The best possibilities for industrial water wells in sand and gravel appear to be in secs. 22, 27, and 34, where the dolomite is generally covered by at least 152 feet of drift, much of which may be water-yielding. Geologic conditions in most of secs. 1, 12, 13, 14, 22, 23, 27, and 34 favor the occurrence of shallow water-bearing sand and gravel beds suitable for drilled wells for private water supplies. Where these beds are missing, wells can normally be drilled through the glacial drift and tap water from open cracks in the underlying Silurian dolomite. In secs. 1, 2, 11, 12, and 13, the dolomite is locally less than 75 feet thick. Wells should not penetrate shale unless the intention is to test formations more than 225 feet deep.

The top of the St. Peter sandstone is estimated to be 530 feet deep beneath the lowlands of sec. 1 and 760 feet beneath the lowlands of sec. 31. The top of the Galesville sandstone is estimated to be 1155 feet deep in sec. 1 and 1470 feet in sec. 31.

Genesee Township (T. 22 N., R. 6 E.)

Dolomite in Genesee Township is exposed in sec. 34; its maximum depth is about 85 feet, in the NW¼ sec. 6. Much of the unconsolidated drift is tight pebbly clay. Local sand and gravel beds suitable for residential water supplies are known to occur within the clay but are not widespread. Geologic conditions do not favor exploration for industrial well sites in sand and gravel. There are dug wells on many farms. Good wells can be drilled in dolomite at most places except in secs. 1 to 3 and 11 to 14, where the bedrock is mostly shale and shaly dolomite, less favorable than firm dolomite for sources of water. In these sections particular attention should be given to possible water-bearing sand or gravel streaks above the solid rock.

The top of the St. Peter sandstone is estimated to be 420 feet deep beneath the lowland in sec. 1 and 800 feet beneath the uplands of sec. 31. The top of the Galesville sandstone is estimated to be 1220 feet deep beneath the lowland in sec. 1 and 1625 feet beneath the uplands of sec. 31.

Jordan Township (T. 22 N., R. 7 E.)

Jordon Township is generally rolling and rough, except for the bottomlands of Elkhorn Valley. The bedrock is buried by as much as 60 feet of glacial drift and stream deposits at scattered upland locations and along Sugar Creek. Water-bearing sand and gravel beds are not abundant except in the Elkhorn and Sugar Creek bottomlands, where conditions may locally be suitable for small industrial wells in shallow sand and gravel deposits. Away from these valleys the bedrock is buried by tight pebbly clay; only scattered thin water-bearing sands and gravels are known. Some drilled wells penetrate water-bearing cracks in dolomite in secs. 1 to 3, 11 to 14, 24, 25, 30, 31, 35, and 36. Elsewhere the bedrock is likely to be shale and shaly limestone, less favorable for water than firm dolomite; therefore particular attention should be given to possible shallow sources of groundwater.

The top of the St. Peter sandstone is estimated to be 480 feet deep beneath the uplands of sec. 1 and 600 feet beneath the uplands of sec. 31. The top of the Galesville sandstone is estimated to be 1150 feet deep in sec. 1 and 1220 feet in sec. 31.

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